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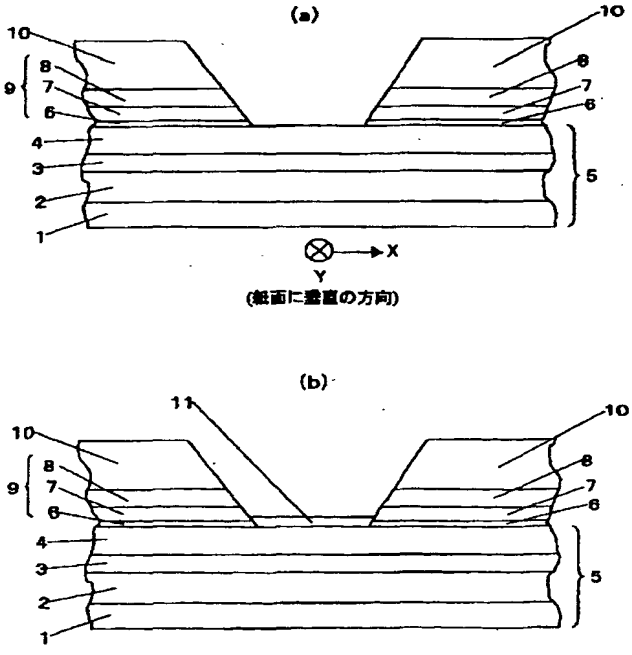
(54)【発明の名称】　薄膜磁気ヘッド及びその製造方法

(57)【要約】
【課題】　高記録密度化に伴う短波長の記録信号を再生するための狭ギャップレングス化された再生ヘッドにおいて、安定した縦バイアスが供給され、高感度で、且つ安定した再生性能を有する薄膜磁気ヘッド及びその製造方法を提供する。
【解決手段】　磁気抵抗効果素子の最上部にあるフリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜で構成された左右一対の積層縦バイアス層を形成することによって、非常に強い交換結合磁界で積層縦バイアス層と対向するフリー磁性層の磁化が固定でき、高感度で再生出力が安定した薄膜磁気ヘッドを得ることができる。



【特許請求の範囲】

【請求項１】　下部シールド層と上部シールド層との間に絶縁材を介して磁気抵抗効果素子を有し、前記磁気抵抗効果素子に接して設けられた縦バイアス層と、信号電流を流すための電極リード層からなる磁気抵抗効果型薄膜磁気ヘッドにおいて、
反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、
前記磁気抵抗効果素子を構成する前記フリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜とからなる左右一対の積層縦バイアス層と、で構成されたことを特徴とする薄膜磁気ヘッド。

【請求項２】　左右一対の前記非磁性膜を介して左右一対の前記強磁性膜に対向している部分の前記磁気抵抗効果素子を構成する前記フリー磁性層の磁化の方向が、左右一対の前記強磁性膜の磁化の方向と逆方向になるような前記積層縦バイアス層を構成する左右一対の前記非磁性膜の膜厚を有することを特徴とする請求項１に記載の薄膜磁気ヘッド。

【請求項３】　左右一対の前記非磁性膜の膜厚が０．４～３ｎｍの範囲にあることを特徴とする請求項１に記載の薄膜磁気ヘッド。

【請求項４】　反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、
前記磁気抵抗効果素子を構成する前記フリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層と、で構成されたことを特徴とする薄膜磁気ヘッド。

【請求項５】　前記フリー磁性層の磁化の方向が、左右一対の前記第１の強磁性膜の磁化の方向と逆方向になるような左右一対の前記第１の非磁性膜の厚さを有し、左右一対の前記第２の強磁性膜の磁化の方向が左右一対の前記第１の強磁性層の磁化方向と逆方向になるような左右一対の前記第２の非磁性膜の厚さを有することを特徴とする請求項４に記載の薄膜磁気ヘッド。

【請求項６】　左右一対の前記第１の非磁性膜の膜厚が、０．４～３ｎｍの範囲にあり、且つ、左右一対の前記第２の非磁性膜の膜厚が０．４～３ｎｍの範囲にあることを特徴とする請求項４に記載の薄膜磁気ヘッド。

【請求項７】　左右一対の前記積層縦バイアス層の間にあり、且つ、前記磁気抵抗効果素子の上面に接したキャップ層を有することを特徴とする請求項１～請求項６のいずれかに記載の薄膜磁気ヘッド。

【請求項８】　前記磁気抵抗効果素子を構成する前記固定磁性層が、非磁性層膜を介して対向する２つの固定磁性層膜を積層した積層固定磁性層で構成されたことを特徴とする請求項１～請求項７のいずれかに記載の薄膜磁気ヘッド。

【請求項９】　前記積層固定磁性層において、前記非磁性層膜を介して対向した前記固定磁性層膜の磁化の方向をお互いに逆の方向になるような前記非磁性層膜の膜厚を有することを特徴とする請求項８に記載の薄膜磁気ヘッド。

【請求項１０】　前記積層固定磁性層において、前記非磁性層膜の膜厚が、０．４～３ｎｍの範囲にあることを特徴とする請求項８に記載の薄膜磁気ヘッド。

【請求項１１】　前記磁気抵抗効果素子を構成する前記フリー磁性層が、その隣り合うフリー磁性層膜の材料を異種の軟磁性材料で複数層積層された積層フリー磁性層で構成されたことを特徴とする請求項１～請求項１０のいずれかに記載の薄膜磁気ヘッド。

【請求項１２】　下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、
前記磁気抵抗効果素子の最上部にある前記フリー磁性層の上に、左右一対の非磁性膜を成膜形成し、その上に左右一対の強磁性膜を積層成膜し、更にその上に、左右一対の反強磁性膜を積層成膜して、前記非磁性膜、前記強磁性膜及び前記反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、
前記積層縦バイアス層の最上部に形成された前記反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項１３】　請求項１２の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層をクリーニングした後、前記フリー磁性層の上に左右一対の非磁性膜、左右一対の強磁性膜及び左右一対の反強磁性膜を積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴とする請求項１２に記載の薄膜磁気ヘッドの製造方法。

【請求項１４】　請求項１２の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように、非磁性層膜、強磁性層膜及び反強磁性層膜を順次積層成膜した後、前記非磁性膜の一部或いは前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の一部が露出するように、少なくとも積層成膜された前記強磁性層膜及び前記反強磁性層膜の一部を削除して、前記フリー磁性層の上に夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を形成することによって、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴とする請求項１２に記載の薄膜磁気ヘッドの製造方法。

【請求項１５】　請求項１２の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように非磁性膜を成膜した後、その上に夫々左右一対の強磁性膜及び反強磁性膜を順次積層成膜形成して、非磁性膜、左右一対の強磁性膜及び左右一対

の反強磁性膜からなる左右一対の縦バイアス層を形成する第２の工程を有することを特徴とする請求項１２に記載の薄膜磁気ヘッドの製造方法。

【請求項１６】　下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、

前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程と、

前記積層縦バイアス層の最上部に形成された前記反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項１７】　請求項１６の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層をクリーニングした後、前記フリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴とする請求項１６に記載の薄膜磁気ヘッドの製造方法。

【請求項１８】　請求項１６の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜を順次積層成膜した後、前記第１の非磁性層膜の一部或いは前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の一部が露出するように、少なくとも積層成膜された前記第１の強磁性層膜、前記第２の非磁性層膜、前記第２の強磁性層膜及び前記反強磁性層膜の一部を削除して、前記フリー磁性層の上に夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を形成することによって、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴とする請求項１６に記載の薄膜磁気ヘッドの製造方法。

【請求項１９】　請求項１６の第２の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように第１の非磁性膜を成膜した後、その上に夫々左右一対の第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜形成して、前記第１の非磁性膜、左右一対の前記第１の強磁性膜、前記第２の非磁性膜、前記第２の強磁性膜及び左右一対の反強磁性膜からなる左右一対の縦バイアス層を形成する第２の工程を有することを特徴とする請求項１６に記載の薄膜磁気ヘッドの製造方法。

【請求項２０】　前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び前記非磁性膜或いは前記磁気抵抗効果素子の露出した上面を覆うように電極リード層膜を成膜し、前記非磁性膜の一部或いは前記磁気抵抗効果素子の一部が露出するように、前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１２～請求項１４或いは請求項１６～請求項１８のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項２１】　前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び最下部に成膜された前記非磁性膜の露出した上面を覆うように電極リード層膜を成膜した後、前記非磁性膜或いは前記磁気抵抗効果素子の一部が露出するように、前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１５に記載の薄膜磁気ヘッドの製造方法。

【請求項２２】　前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び最下部に成膜された前記第１の非磁性膜の露出した上面を覆うように電極リード層膜を成膜した後、前記第１の非磁性膜或いは前記磁気抵抗効果素子の一部が露出するように、前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１９に記載の薄膜磁気ヘッドの製造方法。

【請求項２３】　請求項１２の第３の工程において、レジストを形成して、前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び前記非磁性膜或いは前記磁気抵抗効果素子の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１２～請求項１４或いは請求項１６～請求項１８のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項２４】　レジストを形成して、前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び最下部に成膜された前記非磁性膜の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１５に記載の薄膜磁気ヘッドの製造方法。

【請求項２５】　レジストを形成して、前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び最下部に成膜された前記第１の非磁性膜の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項１９に記載の薄膜磁気ヘッドの製造方法。

【請求項２６】　請求項１２の第２の工程及び第３の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように非磁性層膜、強磁性層膜及び反強磁性層膜を順次積層成膜する第２の工程と、

更に、その上に前記反強磁性層膜を覆うように電極リー

ド層膜を成膜した後、前記非磁性層膜の一部或いは前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の一部が露出するように、少なくとも積層成膜された前記強磁性層膜、前記反強磁性層膜及び前記電極リード層膜の一部を削除して、前記フリー磁性層の上に夫々左右一対の非磁性膜、強磁性膜、反強磁性膜及び電極リード層を形成し、夫々左右一対の前記非磁性膜、前記強磁性膜及び前記反強磁性膜からなる左右一対の積層縦バイアス層及び左右一対の前記電極リード層を形成する第３の工程と、を有することを特徴とする請求項１２に記載の薄膜磁気ヘッドの製造方法。

【請求項２７】　請求項１６の第２の工程及び第３の工程において、前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の上を覆うように第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜を順次積層成膜する第２の工程と、

更に、その上に前記反強磁性層膜を覆うように電極リード層膜を成膜した後、前記第１の非磁性層膜の一部或いは前記磁気抵抗効果素子の最上部に形成された前記フリー磁性層の一部が露出するように、少なくとも積層成膜された前記第１の強磁性層膜、前記第２の非磁性層膜、前記第２の強磁性層膜、前記反強磁性層膜及び前記電極リード層膜の一部を削除して、前記フリー磁性層の上に夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜、反強磁性膜及び電極リード層を形成し、夫々左右一対の前記第１の非磁性膜、前記第１の強磁性膜、前記第２の非磁性膜、前記第２の強磁性膜及び前記反強磁性膜からなる左右一対の積層縦バイアス層及び左右一対の前記電極リード層を形成する第３の工程と、を有することを特徴とする請求項１６に記載の薄膜磁気ヘッドの製造方法。

【請求項２８】　左右一対の前記電極リード層及び前記磁気抵抗効果素子の最上部にある前記フリー磁性層或いは前記非磁性層膜の露出した上面に、酸化防止、耐食性向上のためのキャップ層を成膜する第４の工程を有することを特徴とする請求項１２～請求項２７のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項２９】　下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層を成膜し、更にその上に、第１の固定磁性層膜、非磁性層膜、第２の固定磁性層膜からなる積層固定磁性層を成膜し、その上に、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程を有することを特徴とする請求項１２～請求項２８に記載の薄膜磁気ヘッドの製造方法。

【請求項３０】　下部シールド層の上に成膜された下部ギャップ絶縁層の上に、反強磁性層、固定磁性層及び非磁性導電層を順次積層成膜し、更にその上に、異種の軟磁性材料を用いて第１のフリー磁性層膜、第２のフリー磁性層膜、……、第ｎのフリー磁性層膜（ｎは２以上の正の整数）を積層成膜した積層フリー磁性層を形成して、磁気抵抗効果素子を形成する第１の工程を有することを特徴とする請求項１２～請求項２９のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項３１】　下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成し、更にその上に、キャップ層を成膜する第１の工程と、

レジストを形成して、前記磁気抵抗効果素子の上にある前記キャップ層の一部を削除して前記フリー磁性層を露出させ、露出した前記フリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を順次積層成膜して、前記非磁性膜、前記強磁性膜及び前記反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、

前記積層縦バイアス層の最上部に形成された前記反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程と、を有することを特徴とする薄膜磁気ヘッドの製造方法。

【請求項３２】　請求項３１の第２の工程において、レジストを形成して、前記磁気抵抗効果素子の上に形成された前記キャップ層の一部を削除して前記フリー磁性層を露出させ、露出した前記フリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第３の工程を有することを特徴とする請求項３１に記載の薄膜磁気ヘッドの製造方法。

【請求項３３】　請求項３１の第１の工程において、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層を成膜し、更にその上に、第１の固定磁性層膜、非磁性層膜、第２の固定磁性層膜からなる積層固定磁性層を成膜し、その上に、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成し、更にその上に、キャップ層を成膜する第１の工程を有することを特徴とする請求項３１或いは請求項３２のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項３４】　請求項３１の第１の工程において、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層及び非磁性導電層を順次積層成膜し、更にその上に、異種の軟磁性材料を用いて第１のフリー磁性層膜、第２のフリー磁性層膜、……、第ｎのフリー磁性層膜（ｎは２以上の正の整数）を積層成膜した積層フリー磁性層を形成して、磁気抵抗効果素子を形成し、更にその上に、キャップ層を成膜する第１の工程を有することを特徴とする請求項３１～請求項３３のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項３５】　請求項３１の第３の工程において、前

記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び前記キャップ層の露出した上面を覆うように電極リード層膜を成膜し、前記キャップ層或いは磁気抵抗効果素子の一部が露出するように、前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項３１～請求項３４のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項３６】　請求項３１の第３の工程において、前記積層縦バイアス層の最上部に形成された左右一対の前記反強磁性膜及び前記キャップ層の露出した上面の一部の上に、レジストを形成して、左右一対の電極リード層を形成する第３の工程を有することを特徴とする請求項３１～請求項３４のいずれかに記載の薄膜磁気ヘッドの製造方法。

【請求項３７】　前記磁気抵抗効果素子の最上部にあるフリー磁性層の上面を覆うように、非磁性層膜、強磁性層膜及び反強磁性層膜が順次積層成膜された後、且つ、前記非磁性層膜の一部或いは前記フリー磁性層の一部が露出するように、積層された前記非磁性層膜、前記強磁性層膜及び前記反強磁性層膜の一部を削除して、左右一対の積層縦バイアス層を形成する前に、積層成膜された前記強磁性層膜及び前記磁気抵抗効果素子を構成する前記固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された前記反強磁性層膜及び前記磁気抵抗効果素子の前記反強磁性層に熱処理を加えることを特徴とする請求項１４に記載の薄膜磁気ヘッドの製造方法。

【請求項３８】　前記磁気抵抗効果素子の最上部にある前記フリー磁性層の上面を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜が順次積層成膜された後、且つ、前記第１の非磁性層膜の一部或いは前記フリー磁性層の一部が露出するように、少なくとも積層された前記第１の強磁性層膜、前記第２の非磁性層膜、前記第２の強磁性層膜及び前記反強磁性層膜の一部を削除して、左右一対の積層縦バイアス層を形成する前に、積層成膜された前記第１の強磁性層膜、前記第２の強磁性層膜及び前記磁気抵抗効果素子を構成する前記固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された前記反強磁性層膜及び前記磁気抵抗効果素子の反強磁性層に熱処理を加えることを特徴とする請求項１８に記載の薄膜磁気ヘッドの製造方法。

【請求項３９】　前記磁気抵抗効果素子の最上部にある前記フリー磁性層の上面を覆うように、非磁性層膜、強磁性層膜、反強磁性層膜及び電極リード層膜が順次積層成膜された後、且つ、前記非磁性層膜の一部或いは前記フリー磁性層の一部が露出するように、少なくとも積層された前記強磁性層膜、前記反強磁性層膜及び前記電極リード層膜の一部を削除して、夫々左右一対の積層縦バイアス層及び電極リード層を形成する前に、積層成膜された前記強磁性層膜及び前記磁気抵抗効果素子を構成する前記固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された前記反強磁性層膜及び前記磁気抵抗効果素子の前記反強磁性層に熱処理を加えることを特徴とする請求項２６に記載の薄膜磁気ヘッドの製造方法。

【請求項４０】　前記磁気抵抗効果素子の最上部にある前記フリー磁性層の上面を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜、反強磁性層膜及び電極リード層膜が順次積層成膜された後、且つ、前記第１の非磁性層膜の一部或いは前記フリー磁性層の一部が露出するように、少なくとも積層された前記第１の強磁性層膜、前記第２の非磁性層膜、前記第２の強磁性層膜、前記反強磁性層膜及び前記電極リード層膜の一部を削除して、夫々左右一対の積層縦バイアス層及び電極リード層を形成する前に、積層成膜された前記第１の強磁性層膜、前記第２の強磁性層膜及び前記磁気抵抗効果素子を構成する前記固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された前記反強磁性層膜及び前記磁気抵抗効果素子の前記反強磁性層に熱処理を加えることを特徴とする請求項２７に記載の薄膜磁気ヘッドの製造方法。

【請求項４１】　左右一対の前記電極リード層及び前記磁気抵抗効果素子の最上部にある前記フリー磁性層或いは前記非磁性層膜の露出した上面に、キャップ層が成膜された後、且つ、成膜された前記キャップ層、左右一対の前記電極リード層、左右一対の積層縦バイアス層及び前記磁気抵抗効果素子が所定の形状にパターニングされて削り取られて、上部ギャップ絶縁層が形成される前に、前記積層縦バイアス層を構成する前記強磁性膜及び前記磁気抵抗効果素子を構成する前記固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように前記積層縦バイアス層を構成する前記反強磁性層膜及び前記磁気抵抗効果素子の前記反強磁性層に熱処理を加えることを特徴とする請求項２８に記載の薄膜磁気ヘッドの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、磁気ディスク装置（ＨＤＤ装置）等の磁気記録媒体に対して高密度の記録・再生を行う装置に適用され、特に、磁気抵抗効果素子のフリー磁性層に安定したバイアス磁界を与えて再生効率の高い磁気抵抗効果型薄膜磁気ヘッド及びその製造方法に関するものである。

【０００２】

【従来の技術】近年、磁気ディスク装置（ＨＤＤ装置）等の磁気記録媒体に対する記録・再生において、処理速度の向上と記録容量の大容量化の必要性が増してきており、高記録密度化への取り組みが強化されつつある。

【０００３】以下、従来の薄膜磁気ヘッドについて図面を用いて説明する。

【０００４】図２３及び図２４は、従来の薄膜磁気ヘッドを示す図であり、図２３は斜視概略図、図２４は薄膜磁気ヘッドの正面概略模式図である。

【０００５】例えば、磁気ディスク装置における信号の磁気記録媒体への記録再生に用いられる薄膜磁気ヘッドは、図２３に示すような所謂ＭＲ（ＧＭＲ）インダクティブ複合ヘッドと呼ばれているものが多い。

【０００６】図２３において、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系合金磁性膜等の軟磁性材料で成膜された下部シールド層２３１の上にAl_2O_3、ＡｌＮ或いはSiO_2等の非磁性絶縁材料を用いて下部ギャップ絶縁層２３２が成膜され、更にその上面に磁気抵抗効果素子（ＭＲ素子或いはＧＭＲ素子。以下、ＧＭＲ素子と言う）２３３が積層成膜形成され、ＧＭＲ素子２３３の左右両側端部にＣｏＰｔ合金等の材料で縦バイアス層２３４が成膜される。ＧＭＲ素子２３３の上面とその両側面とのなす交線である稜線に接し、縦バイアス層２３４の上面に成膜するように、Ｃｕ、Ｃｒ或いはＴａ等の材料を用いて電極リード層２３５が形成される。ここで、電極リード層２３５は縦バイアス層２３４の上面及びＧＭＲ素子２３３の一部の上面にかかるようにして、電極リード層２３５を成膜しても良い。次に、電極リード層２３５とＧＭＲ素子２３３の露出した部分の上に、下部ギャップ絶縁層２３２と同様の非磁性絶縁材料を用いて上部ギャップ絶縁層２３６を成膜する。更に、上部ギャップ絶縁層２３６の上に、下部シールド層２３１と同じような軟磁性材料を用いて上部シールド層２３７を成膜形成し、再生用の磁気抵抗効果型薄膜磁気ヘッド部２３８を構成する。

【０００７】次に、上部シールド層２３７の上面に下部ギャップ絶縁層２３２と同様の非磁性絶縁材料を用いて記録ギャップ層２４１を成膜し、更に記録ギャップ層２４１を介して上部シールド層２３７に対向し、且つ、他の部分で上部シールド層２３７に接している上部磁極２４２を軟磁性材料を用いて成膜形成し、記録ギャップ層２４１を介して上部シールド層２３７と上部磁極２４２が対向している部分と上部磁極２４２が上部シールド層２３７に接している部分との間で、上部シールド層２３７と上部磁極２４２から絶縁材（図示せず）を介して絶縁された巻線コイル２４３が設けられて、記録用の誘導型薄膜磁気ヘッド部２４０を構成する。ここで、上部シールド層２３７は再生用磁気抵抗効果型薄膜磁気ヘッド部２３８のシールド機能と記録用誘導型薄膜磁気ヘッド部２４０の下部磁極機能とを兼ね備えた機能を有している。

【０００８】図２４に薄膜磁気ヘッドの再生ヘッド部における磁気抵抗効果素子近傍の正面概略模式図を示すように、下部シールド層２３１の上面に成膜された下部ギャップ絶縁層２３２の上に、ＦｅＭｎ系合金膜、ＰｔＭｎ系合金膜等の材料である反強磁性層２４４、ＮｉＦｅ系合金膜、Ｃｏ、ＣｏＦｅ合金膜等を材料とする固定磁性層２４５、Ｃｕ等を材料とする非磁性導電層２４６、固定磁性層２４５と同様の材料とするフリー磁性層２４７及びＴａ等を材料とするキャップ層２４８が順次積層成膜され、イオンミリング等のエッチング工程で左右両側端部が傾斜した面を持つように削り取られてＧＭＲ素子２３３を形成する。ＧＭＲ素子２３３の左右両側端面に接して、左右一対の縦バイアス層２３４が形成され、その上に左右一対の電極リード層２３５が形成されている。更に、それらの上に、上部ギャップ絶縁層２３６が成膜され、更にその上に、上部シールド層２３７が形成されている。近年、高記録密度化に対応した短波長の記録信号を再生するために、再生ヘッドギャップレングス２４９が益々小さくなってきている。

【０００９】巻線コイル２４３に記録電流が供給されることにより、記録用誘導型薄膜磁気ヘッド部２４０の上部磁極２４２と上部シールド層２３７に記録磁界が発生し、記録ギャップ層２４１を介して対向する上部磁極２４２と上部シールド層２３７との間に漏洩磁束が発生し、磁気記録媒体に記録信号を記録する。また、信号が記録された磁気記録媒体からの信号磁界を再生用磁気抵抗効果型薄膜磁気ヘッド部２３８で再生し、ＧＭＲ素子２３３による抵抗変化に応じた再生信号を電極リード層２３５の端子から検出する。

【００１０】

【発明が解決しようとする課題】しかしながら上記の従来の構成の薄膜磁気ヘッドの再生ヘッド部において、磁気記録媒体に短波長で記録された信号を再生するためには、再生ヘッドギャップレングスを小さくする必要がある。再生ヘッドギャップレングスは下部シールド層の上面から上部シールド層の下面までの距離即ち下部ギャップ絶縁層、ＧＭＲ素子及び上部ギャップ絶縁層の夫々の膜厚の和であり、この距離を小さくすることはＧＭＲ素子の両側にある左右一対の縦バイアス層が下部シールド層或いは上部シールド層に接近することになり、縦バイアス層の磁界が下部シールド層或いは上部シールド層に逃げ易くなり、ＧＭＲ素子のフリー磁性層にかかるバイアス磁界が弱まって、フリー磁性層の磁化の方向が不安定になり、ノイズが増加し、安定した再生信号が得られないという課題があった。

【００１１】本発明は、上記の課題を解決し、縦バイアス層からＧＭＲ素子のフリー磁性層にかかるバイアス磁界を精度良く、安定したものにして、フリー磁性層の磁化の方向を安定させ、バルクハウゼンノイズの発生を抑え、再生性能の良好な磁気抵抗効果型薄膜磁気ヘッド及びその製造方法を提供することを目的とする。

【００１２】

【課題を解決するための手段】この目的を達成するため

に本発明の薄膜磁気ヘッドは、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、磁気抵抗効果素子を構成するフリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜とからなる左右一対の積層縦バイアス層とからなるようにした構成を有している。また、本発明の薄膜磁気ヘッドは、左右一対の非磁性膜を介して左右一対の強磁性膜に対向している部分の磁気抵抗効果素子を構成するフリー磁性層の磁化の方向が、左右一対の強磁性膜の磁化の方向と逆方向になるような積層縦バイアス層を構成する左右一対の非磁性膜の膜厚を有するような構成を有している。

【００１３】この構成によって、適当な膜厚を有する非磁性膜を介して強磁性膜に対向するフリー磁性層を構成することによって、フリー磁性層に直接反強磁性材料を積層させた場合と比較してフリー磁性層の磁化の方向（例えば、Ｘ方向）がより強く固定され、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるフリー磁性層の部分も、安定してＸ方向に向き易くなり、バルクハウゼンノイズの発生が少なく、高感度で安定した再生性能を得ることができる。

【００１４】また、本発明の薄膜磁気ヘッドは、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、磁気抵抗効果素子を構成するフリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層とからなるようにした構成を有している。また、本発明の薄膜磁気ヘッドは、フリー磁性層の磁化の方向が、左右一対の第１の強磁性膜の磁化の方向と逆方向になるような左右一対の第１の非磁性膜の厚さを有し、左右一対の第２の強磁性膜の磁化の方向が左右一対の第１の強磁性層の磁化方向と逆方向になるような左右一対の第２の非磁性膜の厚さを有するような構成を有している。

【００１５】この構成によって、適当な膜厚を有する左右一対の第１の非磁性膜を介して左右一対の第１の強磁性膜に対向するフリー磁性層は、フリー磁性層に直接反強磁性材料を積層させた場合と比較して、第１の強磁性膜との交換結合磁界が非常に強く、左右一対の第１の強磁性膜に対向する部分のフリー磁性層の磁化の方向は非常に安定したものとなり、左右一対の第１の強磁性膜に対向している部分の間にあるフリー磁性層の磁化の方向も同じ方向となり、更に、積層縦バイアス層として適当な膜厚の第２の非磁性膜を介して第１の強磁性膜と第２の強磁性膜と対向させることによって、端面磁荷による漏れ磁界をお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、外部磁界に対して高感度な、安定したものとなり、優れた再生性能を得ることができる。

【００１６】また、本発明の薄膜磁気ヘッドの製造方法は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の最上部にあるフリー磁性層の上に、左右一対の非磁性膜を成膜形成し、その上に左右一対の強磁性膜を積層成膜し、更にその上に、左右一対の反強磁性膜を積層成膜して、非磁性膜、強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有している。また、本発明の薄膜磁気ヘッドの製造方法は、磁気抵抗効果素子の最上部に形成されたフリー磁性層をクリーニングした後、フリー磁性層の上に左右一対の非磁性膜、左右一対の強磁性膜及び左右一対の反強磁性膜を積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程を有している。また、本発明の薄膜磁気ヘッドの製造方法は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成し、更にその上に、キャップ層を成膜する第１の工程と、レジストを形成して、磁気抵抗効果素子の上にあるキャップ層の一部を削除してフリー磁性層を露出させ、露出したフリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を順次積層成膜して、非磁性膜、強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有している。

【００１７】この方法によって、フリー磁性層に磁化の方向を与える縦バイアス層として積層縦バイアス層とした構成とし、左右一対の非磁性膜を介して強磁性膜に対向したフリー磁性層は、その対向している部分において、フリー磁性層が直接反強磁性膜に接している場合と比較して、非常に強い強磁性膜との交換結合磁界が得られ、フリー磁性層の磁化の方向を安定して保持し、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるフリー磁性層の部分も、安定して左右一対の強磁性膜に対向している左右のフリー磁性層の部分と同じ方向に向き易くなり、バルクハウゼンノイズの発生が少なく、高感度な安定した再生性能を有する再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００１８】また、本発明の薄膜磁気ヘッドの製造方法は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の最上部に

形成されたフリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有している。

【００１９】この方法によって、フリー磁性層に磁化の方向を与える縦バイアス層として積層縦バイアス層とした構成とし、左右一対の非磁性膜を介して強磁性膜に対向したフリー磁性層は、その対向している部分において、フリー磁性層が直接反強磁性膜に接している場合と比較して、非常に強い強磁性膜との交換結合磁界が得られ、フリー磁性層の磁化の方向を安定して保持し、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるフリー磁性層の部分も、安定して左右一対の強磁性膜に対向している左右のフリー磁性層の部分と同じ方向に向き易くなり、更に、積層縦バイアス層の強磁性膜の端面磁荷による漏れ磁界を第１の強磁性膜と第２の強磁性膜でお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、フリー磁性層の磁化の方向がより安定したものとなり、より一層安定した再生性能を有する再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００２０】

【発明の実施の形態】本発明の請求項１に記載の発明は、下部シールド層と上部シールド層との間に絶縁材を介して磁気抵抗効果素子を有し、磁気抵抗効果素子に接して設けられた縦バイアス層と、信号電流を流すための電極リード層からなる磁気抵抗効果型薄膜磁気ヘッドにおいて、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、磁気抵抗効果素子を構成するフリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜とからなる左右一対の積層縦バイアス層とで構成されたことを特徴としたものであり、また、本発明の請求項２に記載の発明は、左右一対の非磁性膜を介して左右一対の強磁性膜に対向している部分の磁気抵抗効果素子を構成するフリー磁性層の磁化の方向が、左右一対の強磁性膜の磁化の方向と逆方向になるような積層縦バイアス層を構成する左右一対の非磁性膜の膜厚を有することを特徴としたものであり、また、本発明の請求項３に記載の発明は、左右一対の非磁性膜の膜厚が０．４～３ｎｍの範囲にあることを特徴としたものであり、また、本発明の請求項７に記載の発明は、左右一対の積層縦バイアス層の間にあり、且つ、磁気抵抗効果素子の上面に接したキャップ層を有することを特徴としたものであり、また、本発明の請求項８に記載の発明は、磁気抵抗効果素子を構成する固定磁性層が、非磁性層膜を介して対向する２つの固定磁性層膜を積層した積層固定磁性層で構成されたことを特徴としたものであり、また、本発明の請求項９に記載の発明は、積層固定磁性層において、非磁性層膜を介して対向した固定磁性層膜の磁化の方向をお互いに逆の方向になるような非磁性層膜の膜厚を有することを特徴としたものであり、また、本発明の請求項１１に記載の発明は、磁気抵抗効果素子を構成するフリー磁性層が、その隣り合うフリー磁性層膜の材料を異種の軟磁性材料で複数層積層された積層フリー磁性層で構成されたことを特徴としたものであり、縦バイアス層として、強磁性膜と反強磁性膜とを積層し、反強磁性膜との交換結合磁界によって、強磁性膜の磁化の方向が一定の方向（例えば、－Ｘ方向）に揃えられ、且つ、適当な膜厚を有する非磁性膜を介して強磁性膜に対向するフリー磁性層を構成することによって、フリー磁性層に直接反強磁性材料を積層させた場合と比較してフリー磁性層の磁化の方向（例えば、Ｘ方向）がより強く固定され、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるＧＭＲ素子を構成するフリー磁性層の部分も、安定してＸ方向に向き易くなり、非常に安定なものとなり、バルクハウゼンノイズの発生が少なく、高感度で安定した再生性能を得ることができるという作用を有している。

【００２１】また、本発明の請求項４に記載の発明は、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層からなる磁気抵抗効果素子と、磁気抵抗効果素子を構成するフリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層とで構成されたことを特徴としたものであり、また、本発明の請求項５に記載の発明は、フリー磁性層の磁化の方向が、左右一対の第１の強磁性膜の磁化の方向と逆方向になるような左右一対の第１の非磁性膜の厚さを有し、左右一対の第２の強磁性膜の磁化の方向が左右一対の第１の強磁性層の磁化方向と逆方向になるような左右一対の第２の非磁性膜の厚さを有することを特徴としたものであり、また、本発明の請求項６に記載の発明は、左右一対の第１の非磁性膜の膜厚が、０．４～３ｎｍの範囲にあり、且つ、左右一対の第２の非磁性膜の膜厚が０．４～３ｎｍの範囲にあることを特徴としたものであり、第２の強磁性膜と反強磁性膜との間の交換結合磁界により、第２の強磁性膜の磁化の方向が一定の方向に揃えられ、且つ、適当な膜厚を有する左右一対の第２の非磁性膜を介して左右一対の第２の強磁性膜に対向する第１の強磁性膜の磁化の方向が第２の強磁性膜の磁化の方向と逆方向に揃えられ、また、適当な膜厚を有する左右一対の第１の非磁性膜を介して左右一対の第１の強磁性膜に対向するフリー磁性層は、第１の強磁性膜との交換結合磁界が非常に強く、左右一対の第１の強磁性膜に対向する部分のフリー磁性層の磁化の方向は第１の強磁性

膜の磁化の方向と反対方向に向き、非常に安定したものとなり、左右一対の第１の強磁性膜に対向している部分の間にあるフリー磁性層の磁化の方向も同じ方向となり、更に、積層縦バイアス層として第２の非磁性膜を介して第１の強磁性膜と第２の強磁性膜と対向させることによって、端面磁荷による漏れ磁界をお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、外部磁界に対して高感度な、安定したものとなり、優れた再生性能を得ることができる。

【００２２】また、本発明の請求項１２に記載の発明は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の最上部にあるフリー磁性層の上に、左右一対の非磁性膜を成膜形成し、その上に左右一対の強磁性膜を積層成膜し、更にその上に、左右一対の反強磁性膜を積層成膜して、非磁性膜、強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項１３に記載の発明は、請求項１２の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層をクリーニングした後、フリー磁性層の上に左右一対の非磁性膜、左右一対の強磁性膜及び左右一対の反強磁性膜を積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項１４に記載の発明は、請求項１２の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上を覆うように、非磁性層膜、強磁性層膜及び反強磁性層膜を順次積層成膜した後、非磁性膜の一部或いは磁気抵抗効果素子の最上部に形成されたフリー磁性層の一部が露出するように、少なくとも積層成膜された強磁性層膜及び反強磁性層膜の一部を削除して、フリー磁性層の上に夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を形成することによって、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項１５に記載の発明は、請求項１２の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上を覆うように非磁性膜を成膜した後、その上に夫々左右一対の強磁性膜及び反強磁性膜を順次積層成膜形成して、非磁性膜、左右一対の強磁性膜及び左右一対の反強磁性膜からなる左右一対の縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項２０に記載の発明は、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び磁気抵抗効果素子の露出した上面を覆うように電極リード層膜を成膜し、磁気抵抗効果素子の一部が露出するように、電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２１に記載の発明は、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び最下部に成膜された非磁性膜の露出した上面を覆うように電極リード層膜を成膜した後、非磁性膜或いは磁気抵抗効果素子の一部が露出するように、電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２３に記載の発明は、請求項１２の第３の工程において、レジストを形成して、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び磁気抵抗効果素子の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２４に記載の発明は、レジストを形成して、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び最下部に成膜された非磁性膜の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２６に記載の発明は、請求項１２の第２の工程及び第３の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上を覆うように非磁性層膜、強磁性層膜及び反強磁性層膜を順次積層成膜する第２の工程と、更に、その上に反強磁性層膜を覆うように電極リード層膜を成膜した後、非磁性層膜の一部或いは磁気抵抗効果素子の最上部に形成されたフリー磁性層の一部が露出するように、少なくとも積層成膜された強磁性層膜、反強磁性層膜及び電極リード層膜の一部を削除して、前記フリー磁性層の上に夫々左右一対の非磁性膜、強磁性膜、反強磁性膜及び電極リード層を形成し、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層及び左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項２８に記載の発明は、左右一対の電極リード層及び磁気抵抗効果素子の最上部にあるフリー磁性層或いは非磁性層膜の露出した上面に、酸化防止、耐食性向上のためのキャップ層を成膜する第４の工程を有することを特徴としたものであり、また、本発明の請求項２９に記載の発明は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層を成膜し、更にその上に、第１の固定磁性層膜、非磁性層膜、第２の固定磁性層膜からなる積層固定磁性層を成膜し、その上に、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程を有することを特徴としたものであり、また、本発明の請求項３０に記載の発明は、下部シールド層の上に成膜された下部ギャップ絶縁層の上に、反強磁性層、固定磁性層及び非磁性導電

層を順次積層成膜し、更にその上に、異種の軟磁性材料を用いて第１のフリー磁性層膜、第２のフリー磁性層膜、……、第ｎのフリー磁性層膜（ｎは２以上の正の整数）を積層成膜した積層フリー磁性層を形成して、磁気抵抗効果素子を形成する第１の工程を有することを特徴としたものであり、また、本発明の請求項３１に記載の発明は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成し、更にその上に、キャップ層を成膜する第１の工程と、レジストを形成して、磁気抵抗効果素子の上にあるキャップ層の一部を削除してフリー磁性層を露出させ、露出したフリー磁性層の上に、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を順次積層成膜して、非磁性膜、強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項３５に記載の発明は、請求項３１の第３の工程において、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及びキャップ層の露出した上面を覆うように電極リード層膜を成膜し、キャップ層の一部が露出するように、電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項３６に記載の発明は、請求項３１の第３の工程において、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及びキャップ層の露出した上面の一部の上に、レジストを形成して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、縦バイアス層として、強磁性膜と反強磁性膜とを積層し、反強磁性膜との交換結合磁界によって、強磁性膜の磁化の方向が一定の方向（例えば、－Ｘ方向）に揃えられ、且つ、適当な膜厚を有する非磁性膜を介して強磁性膜に対向するフリー磁性層を構成することによって、フリー磁性層に直接反強磁性材料を積層させた場合と比較してフリー磁性層の磁化の方向（例えば、Ｘ方向）がより強く固定され、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるＧＭＲ素子を構成するフリー磁性層の部分も、安定してＸ方向に向き易くなり、非常に安定なものとなり、バルクハウゼンノイズの発生が少なく、高感度で安定した再生性能の実現を図った薄膜磁気ヘッドを作製することができるという作用を有している。

【００２３】また、本発明の請求項１６に記載の発明は、下部シールド層の上に成膜された下部ギャップ絶縁層の上面に、反強磁性層、固定磁性層、非磁性導電層及びフリー磁性層を順次積層成膜して、磁気抵抗効果素子を形成する第１の工程と、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程と、積層縦バイアス層の最上部に形成された反強磁性膜の上に、左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項１７に記載の発明は、請求項１６の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層をクリーニングした後、フリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項１８に記載の発明は、請求項１６の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜を順次積層成膜した後、第１の非磁性層膜の一部或いは磁気抵抗効果素子の最上部に形成されたフリー磁性層の一部が露出するように、少なくとも積層成膜された第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜の一部を削除して、フリー磁性層の上に夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を形成することによって、左右一対の積層縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項１９に記載の発明は、請求項１６の第２の工程において、磁気抵抗効果素子の最上部に形成されたフリー磁性層の上を覆うように第１の非磁性膜を成膜した後、その上に夫々左右一対の第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜形成して、第１の非磁性膜、左右一対の第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び左右一対の反強磁性膜からなる左右一対の縦バイアス層を形成する第２の工程を有することを特徴としたものであり、また、本発明の請求項２２に記載の発明は、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び最下部に成膜された第１の非磁性膜の露出した上面を覆うように電極リード層膜を成膜した後、第１の非磁性膜或いは磁気抵抗効果素子の一部が露出するように、前記電極リード層膜の一部を削除して、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２５に記載の発明は、レジストを形成して、積層縦バイアス層の最上部に形成された左右一対の反強磁性膜及び最下部に成膜された第１の非磁性膜の露出した上面の一部の上に、左右一対の電極リード層を形成する第３の工程を有することを特徴としたものであり、また、本発明の請求項２７に記載の発明は、請求項１６の第２の工程及び第３の工程において、磁気抵抗効果素子の最上部に形成されたフリー

磁性層の上を覆うように第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜を順次積層成膜する第２の工程と、更に、その上に反強磁性層膜を覆うように電極リード層膜を成膜した後、第１の非磁性層膜の一部或いは磁気抵抗効果素子の最上部に形成されたフリー磁性層の一部が露出するように、少なくとも積層成膜された第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜、反強磁性層膜及び電極リード層膜の一部を削除して、フリー磁性層の上に夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜、反強磁性膜及び電極リード層を形成し、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜からなる左右一対の積層縦バイアス層及び左右一対の電極リード層を形成する第３の工程とを有することを特徴としたものであり、また、本発明の請求項３２に記載の発明は、請求項３１の第２の工程において、レジストを形成して、磁気抵抗効果素子の上に形成されたキャップ層の一部を削除してフリー磁性層を露出させ、露出したフリー磁性層の上に、夫々左右一対の第１の非磁性膜、第１の強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜を順次積層成膜して、左右一対の積層縦バイアス層を形成する第３の工程を有することを特徴としたものであり、第２の強磁性膜と反強磁性膜との間の交換結合磁界により、第２の強磁性膜の磁化の方向が一定の方向に揃えられ、且つ、適当な膜厚を有する左右一対の第２の非磁性膜を介して左右一対の第２の強磁性膜に対向する第１の強磁性膜の磁化の方向が第２の強磁性膜の磁化の方向と逆方向に揃えられ、また、適当な膜厚を有する左右一対の第１の非磁性膜を介して左右一対の第１の強磁性膜に対向するフリー磁性層は、第１の強磁性膜との交換結合磁界が非常に強く、左右一対の第１の強磁性膜に対向する部分のフリー磁性層の磁化の方向は第１の強磁性膜の磁化の方向と反対方向に向き、非常に安定したものとなり、左右一対の第１の強磁性膜に対向している部分の間にあるフリー磁性層の磁化の方向も同じ方向となり、更に、積層縦バイアス層として第２の非磁性膜を介して第１の強磁性膜と第２の強磁性膜と対向させることによって、端面磁荷による漏れ磁界をお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、外部磁界に対して高感度な、安定したものとなり、優れた再生性能の実現を図った薄膜磁気ヘッドを作製することができるという作用を有している。

【００２４】また、本発明の請求項３７に記載の発明は、磁気抵抗効果素子の最上部にあるフリー磁性層の上面を覆うように、非磁性層膜、強磁性層膜及び反強磁性層膜が順次積層成膜された後、且つ、非磁性層膜の一部或いはフリー磁性層の一部が露出するように、少なくとも積層された強磁性層膜及び反強磁性層膜の一部を削除して、左右一対の積層縦バイアス層を形成する前に、積層成膜された強磁性層膜及び磁気抵抗効果素子を構成する固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された反強磁性層膜及び磁気抵抗効果素子の反強磁性層に熱処理を加えることを特徴としたものであり、また、本発明の請求項３８に記載の発明は、磁気抵抗効果素子の最上部にあるフリー磁性層の上面を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜が順次積層成膜された後、且つ、第１の非磁性層膜の一部或いはフリー磁性層の一部が露出するように、少なくとも積層された第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜及び反強磁性層膜の一部を削除して、左右一対の積層縦バイアス層を形成する前に、積層成膜された第１の強磁性層膜、第２の強磁性層膜及び磁気抵抗効果素子を構成する固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された反強磁性層膜及び磁気抵抗効果素子の反強磁性層に熱処理を加えることを特徴としたものであり、また、本発明の請求項３９に記載の発明は、磁気抵抗効果素子の最上部にあるフリー磁性層の上面を覆うように、非磁性層膜、強磁性層膜、反強磁性層膜及び電極リード層膜が順次積層成膜された後、且つ、非磁性層膜の一部或いはフリー磁性層の一部が露出するように、少なくとも積層された強磁性層膜、反強磁性層膜及び電極リード層膜の一部を削除して、夫々左右一対の積層縦バイアス層及び電極リード層を形成する前に、積層成膜された強磁性層膜及び磁気抵抗効果素子を構成する固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された反強磁性層膜及び磁気抵抗効果素子の前記反強磁性層に熱処理を加えることを特徴としたものであり、また、本発明の請求項４０に記載の発明は、磁気抵抗効果素子の最上部にあるフリー磁性層の上面を覆うように、第１の非磁性層膜、第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜、反強磁性層膜及び電極リード層膜が順次積層成膜された後、且つ、第１の非磁性層膜の一部或いはフリー磁性層の一部が露出するように、少なくとも積層された第１の強磁性層膜、第２の非磁性層膜、第２の強磁性層膜、反強磁性層膜及び電極リード層膜の一部を削除して、夫々左右一対の積層縦バイアス層及び電極リード層を形成する前に、積層成膜された第１の強磁性層膜、第２の強磁性層膜及び磁気抵抗効果素子を構成する固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層成膜された反強磁性層膜及び磁気抵抗効果素子の反強磁性層に熱処理を加えることを特徴としたものであり、また、本発明の請求項４１に記載の発明は、左右一対の電極リード層及び磁気抵抗効果素子の最上部にあるフリー磁性層或いは非磁性層膜の露出した上面に、キャップ層が成膜された後、且つ、成膜されたキ

ャップ層、左右一対の電極リード層、左右一対の積層縦バイアス層及び磁気抵抗効果素子が所定の形状にパターニングされて削り取られて、上部ギャップ絶縁層が形成される前に、積層縦バイアス層を構成する強磁性膜及び磁気抵抗効果素子を構成する固定磁性層の夫々の磁化の方向が、夫々の所定の方向になるように積層縦バイアス層を構成する反強磁性層膜及び磁気抵抗効果素子の反強磁性層に熱処理を加えることを特徴としたものであり、磁気抵抗効果素子を構成する固定磁性層及び積層縦バイアス層の強磁性膜と強い交換結合磁界によって結合されたフリー磁性層の夫々の磁化の方向が所定の方向になるように設定するための夫々の熱処理が効率良く連続して実施することができ、また、エッチング或いはパターニング等の方法によって所定の形状に形成された積層縦バイアス層の強磁性膜の端面における磁化も同じ方向に整列して揃うことになり、非磁性膜を介して対向したフリー磁性層と安定した交換結合磁界で結合させることができるという作用を有している。

【００２５】以下、本発明の実施の形態について、図面を用いて説明する。

【００２６】（実施の形態１）図１は、本発明の実施の形態１を示す説明概要図であり、磁気記録媒体に対向するヘッド摺動面側から見た磁気抵抗効果素子近傍を模式的に示した図である。

【００２７】図１（ａ）において、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系微粒子磁性膜等の軟磁性材料を素材とする下部シールド層（図示せず）の上に形成されたAl_2O_3、ＡｌＮ或いはSiO_2等の非磁性絶縁材料を用いた下部ギャップ絶縁層（図示せず）の上に、ＩｒＭｎ、αFe_2O_3、ＦｅＭｎ系合金膜、ＰｔＭｎ系合金膜等の材料である反強磁性層１、ＮｉＦｅ系合金膜、Ｃｏ、ＣｏＦｅ合金膜等を材料とする固定磁性層２、Ｃｕ等を材料とする非磁性導電層３及び固定磁性層２と同様の強磁性材料を材料とするフリー磁性層４で構成された磁気抵抗効果素子５（ＭＲ素子或いはＧＭＲ素子。以下、ＧＭＲ素子と言う）が構成されている。更に、ＧＭＲ素子５を構成するフリー磁性層４の上面に、夫々左右一対のＲｕ等の非磁性材料を用いた非磁性膜６、その上にＧＭＲ素子５を構成するフリー磁性層４と同じような材料を用いた強磁性膜７及びＧＭＲ素子５を構成する反強磁性層１と同じような材料を用いた反強磁性材料（場合によっては、酸化金属は用いない方が良い）を用いた反強磁性膜８とからなる左右一対の積層縦バイアス層９が構成されている。強磁性膜７の磁化の方向は反強磁性膜８との交換結合磁界によって、一定の方向に揃えられ、安定した状態に保たれる。従って、非磁性膜６を介して強磁性膜７に対向するフリー磁性層４の磁化の方向は、介在する非磁性膜６の膜厚に対応して同じ方向或いは逆の方向に非常に安定した状態を保つことになる。更に、それらの上に、従来例と同様に、Ｃｕ、Ｃｒ或いはＴａ等の材料を用いた左右一対の電極リード層１０があり、その上に、図示していないが、全体を覆うように下部ギャップ絶縁層と同様の絶縁材料を用いて上部ギャップ絶縁層が形成され、更に、その上に、下部シールド層と同様の軟磁性材料を用いて上部シールド層が形成されて、再生ヘッド用磁気抵抗効果型薄膜磁気ヘッドが構成される。

【００２８】尚、左右一対の電極リード層１０及びフリー磁性層４の露出した部分の上面を覆うようにＴａ等を材料としてキャップ層を形成して酸化を防ぐようにしても良いということは言うまでもない。

【００２９】ＧＭＲ素子５を構成する固定磁性層２の磁化の方向が磁気記録媒体に対向するヘッド摺動面と直行する方向Ｙ（図１の紙面に垂直な方向）になるように、Ｙ方向に磁場が与えられて、所定の温度及び時間で熱処理（アニール）され、反強磁性層１との交換結合磁界により、固定磁性層２の磁化の方向はＹ方向に固定される。一方、積層縦バイアス層９を構成する左右一対の強磁性膜７の磁化の方向を固定磁性層２の磁化の方向に略直行した方向（図１において、Ｘ或いは－Ｘ方向）になるようにする。強磁性膜７の磁化の方向を設定するための磁場の強さ、熱処理温度或いは処理時間の条件の内、少なくとも１つの条件が、固定磁性層２の磁化の方向の設定条件と異なる条件で磁化の方向が設定できるような反強磁性膜８の材料を選定して用いることが必要である。

【００３０】更に、強磁性膜７と強い交換結合磁界を発生して、強磁性膜７の磁化の方向とは逆方向の磁化の方向がフリー磁性層４に与えられるように、左右一対の積層縦バイアス層９を構成する左右一対の非磁性膜６の膜厚の厚さを設定して、フリー磁性層４の磁化の方向（例えば、Ｘ方向の場合）を強磁性膜７の磁化の方向と逆方向の磁化の方向（－Ｘ方向）にする。非磁性膜６の膜厚が小さければ、フリー磁性層４の磁化の方向は強磁性膜７の磁化の方向と同じ方向のままであり、他方、非磁性膜６の膜厚が大きすぎるとフリー磁性層４の磁化の方向は再び元の方向即ち強磁性膜７の磁化の方向と同じ方向になるというように、膜厚によって磁化の方向が同じ方向或いは逆の方向と周期的に変化し、磁界の強さも徐々に減衰してゆく。従って、非磁性膜６の膜厚は適切な範囲に設定する必要がある。検討結果によれば、非磁性膜６の膜厚は、用いる非磁性材料により異なり、表１の如き結果を得た。

【００３１】

【表１】

使用する非磁性材料	磁化の方向を反対の向きにする膜厚
Ｒｕ	０．４～０．８ｎｍ
Ｃｕ	０．９ｎｍ近傍、２．０ｎｍ近傍
Ａｇ，Ａｕ	２～３ｎｍ
Ｉｒ	１．３ｎｍ近傍

【００３２】また、図１（ｂ）に示すように、前述の実施の形態１における左右一対の積層縦バイアス層９の間にあり、磁気抵抗効果素子５の最上部にあるフリー磁性層４の上面に接しているＴａ等の非磁性材料を用いてキャップ層１１が形成されていても良い。

【００３３】以上のように本実施の形態１によれば、フリー磁性層に磁化の方向を与える縦バイアス層として、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を積層した積層縦バイアス層とした構成として、強磁性膜と反強磁性膜とを積層し、反強磁性膜との交換結合磁界によって、強磁性膜の磁化の方向が一定の方向（例えば、－Ｘ方向）に揃えられ、且つ、適当な膜厚で形成された非磁性膜を介して強磁性膜に対向するフリー磁性層を構成することによって、フリー磁性層に直接反強磁性材料を積層させた場合と比較してフリー磁性層の磁化の方向（例えば、Ｘ方向）がより強く固定され、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるＧＭＲ素子を構成するフリー磁性層の部分も、安定してＸ方向に向き易くなり、非常に安定なものとなり、バルクハウゼンノイズの発生が少なく、再生感度が高く、再生性能を安定化させることができる。

【００３４】（実施の形態２）図２は、本発明の実施の形態２を示す説明概要図であり、磁気記録媒体に対向するヘッド摺動面側から見た磁気抵抗効果素子近傍の模式図である。

【００３５】図２（ａ）において、前述の実施の形態１と同様に、下部シールド層（図示せず）の上に成膜された下部ギャップ絶縁層（図示せず）の上に反強磁性層１、固定磁性層２、非磁性導電層３及びフリー磁性層４が順次積層成膜されてＧＭＲ素子５が形成されている。更に、その上に、前述の実施の形態１と同様の材料を用いて、夫々左右一対の第１の非磁性膜２００１、第１の強磁性膜２００２、第２の非磁性膜２００３、第２の強磁性膜２００４及び反強磁性膜２００５が順次積層成膜されて左右一対の積層縦バイアス層２１が形成されている。尚、第１の非磁性膜２００１及び第２の非磁性膜２００３の膜厚によって、それらに隣接する第１の強磁性膜２００２とフリー磁性層４、第１の強磁性膜２００２と第２の強磁性膜２００４との磁化の方向は同じ方向になったり、逆の方向になったりするのは実施の形態１と同じである。また、実施の形態１と同様に、左右一対の積層縦バイアス層２１の上には左右一対の電極リード層２２が形成され、電極リード層２２及び露出したＧＭＲ素子５の上に上部ギャップ絶縁層（図示せず）が成膜され、更に、その上に、上部シールド層（図示せず）が形成され、再生ヘッド用磁気抵抗効果型薄膜磁気ヘッドが形成されている。

【００３６】また、図２（ｂ）に示すように、前述の実施の形態２における夫々左右一対の第１の非磁性膜２００１、第１の強磁性膜２００２、第２の非磁性膜２００３、第２の強磁性膜２００４及び反強磁性膜２００５からなる左右一対の積層縦バイアス層２１の間にあり、且つ、磁気抵抗効果素子５を構成するフリー磁性層４の上面に接するようにキャップ層２３が形成されていても良い。

【００３７】以上のように本実施の形態２によれば、前述の実施の形態１と同じような効果があり、第２の強磁性膜の上に反強磁性膜を成膜形成することによって、第２の強磁性膜と反強磁性膜との間の交換結合磁界により、第２の強磁性膜の磁化の方向が一定の方向に揃えられ、且つ、適当な膜厚を有する左右一対の第２の非磁性膜を介して左右一対の第２の強磁性膜に対向する第１の強磁性膜の磁化の方向が第２の強磁性膜の磁化の方向と逆方向に揃えられ、更に、適当な膜厚で形成された第１の非磁性膜を介して第１の強磁性膜に対向させてフリー磁性層を構成することによって、フリー磁性層に直接反強磁性材料を積層させた場合と比較してフリー磁性層の磁化の方向（例えば、Ｘ方向）がより強く固定され、左右一対の第１の強磁性膜に対向している部分のフリー磁性層の磁化の方向は非常に安定したものとなり、左右一対の第１の強磁性膜に対向しているフリー磁性層の部分の間にあるフリー磁性層の部分の磁化の方向も安定して同じ方向に向き易くなり、更に、積層縦バイアス層として第２の非磁性膜を介して第１の強磁性膜と第２の強磁性膜と対向させ、お互いの磁化の方向が逆の方向になるように第２の非磁性膜の膜厚にすることによって、第１の強磁性膜と第２の強磁性膜が端面磁荷による漏れ磁界をお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、外部磁界に対して高感度な、安定したものとなり、再生性能をより一層安定にすることができる。

【００３８】尚、前述の実施の形態１及び２において、固定磁性層及びフリー磁性層は、夫々単一の材料で形成されているように記述されているが、図２（ｃ）に示すように、固定磁性層を第１の固定磁性層膜２００６、第１の非磁性層膜２００７、第２の固定磁性層膜２００８からなる積層固定磁性層２４であっても良い。この時、

固定磁性層膜の間に介在する非磁性層膜の膜厚によって、その非磁性層膜を介して対向する固定磁性層膜の磁化の方向が夫々同じ方向になったり、逆方向になったりするが、逆の方向になるように非磁性層膜の膜厚を設定しなければならない。また、図２（ｄ）に示すように、フリー磁性層も第１のフリー磁性層膜２０１１、第２のフリー磁性層膜２０１２……第ｎのフリー磁性層膜２０１３からなり、互いに隣り合うフリー磁性層膜は異種の軟磁性材料を用いた積層フリー磁性層２５であっても良い。

【００３９】（実施の形態３）図３～図１１は、本発明の実施の形態３を示す概略説明図であり、再生用磁気抵抗効果型薄膜磁気ヘッドの製造工程を説明するための工程概要説明図で、磁気記録媒体に対向するヘッド摺動面の近傍におけるヘッド摺動面と平行な面で切断した断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００４０】図３に示すように、ＡｌＴｉＣ等を材料とした基板３０の上に成膜され、パーマロイ、Ｃｏ系アモルファス磁性膜或いはＦｅ系微粒子磁性膜等の軟磁性材料を素材とする下部シールド層３１の上にAl_2O_3、ＡｌＮ或いはSiO_2等の非磁性絶縁材料を用いて下部ギャップ絶縁層３２を成膜する。

【００４１】第１の工程として、図４（ａ）に示すように、下部ギャップ絶縁層３２の上に、ＩｒＭｎ系、αFe_2O_3、ＮｉＯ、ＦｅＭｎ系合金膜、ＮｉＭｎ系合金膜或いはＰｔＭｎ系合金膜等の材料を用いて反強磁性層４１を成膜し、更に、図４（ｂ）に示すように、その上に、ＮｉＦｅ系合金膜、Ｃｏ或いはＣｏＦｅ合金膜等を材料として固定磁性層４２を成膜する。次に、図４（ｃ）に示すように、固定磁性層４２の上に、Ｃｕ等を材料とする非磁性導電層４３を成膜する。更に、図４（ｄ）に示すように、非磁性導電層４３の上に、固定磁性層４２と同様の材料を用いてフリー磁性層４４を成膜し、反強磁性層４１、固定磁性層４２、非磁性導電層４３及びフリー磁性層４４が薄膜で順次積層成膜されたＧＭＲ素子４５を形成する。

【００４２】第２の工程として、図５（ａ）に示すように、ＧＭＲ素子４５の上に、茸型のレジスト５１を形成して、ＧＭＲ素子４５を構成するフリー磁性層４４の上に、Ｒｕ等の非磁性材料を用いて左右一対の非磁性膜５２を成膜する。尚、この時の非磁性膜５２の膜厚は、後工程で成膜され、磁化される強磁性膜との交換結合磁界によりフリー磁性層４４の磁化の方向が強磁性膜の磁化の方向と逆方向となるような左右一対の非磁性膜５２の膜厚で成膜する。更に、その上に、ＧＭＲ素子４５を構成するフリー磁性層４４と同様の材料を用いて左右一対の強磁性膜５３を成膜する。更に、その上に、ＧＭＲ素子４５の反強磁性層４１と同様の材料（但し、場合によっては酸化金属膜を用いない方が良い）を用いて左右一対の反強磁性膜５４を成膜形成し、夫々左右一対の非磁性膜５２、強磁性膜５３及び反強磁性膜５４で構成される左右一対の積層縦バイアス層５５を形成する。尚、この時、用いられる反強磁性膜５４の材料は、ＧＭＲ素子４５を構成する固定磁性層４２に磁化の方向付けをする反強磁性層４１の熱処理条件（磁場の強さ或いは熱処理温度或いは熱処理時間）のうちの少なくともいずれか１つの条件が異なる材料に設定する必要がある。

【００４３】第３の工程として、図５（ｂ）に示すように、左右一対の反強磁性膜５４の上に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて左右一対の電極リード層５６を成膜する。

【００４４】第４の工程として、図６（ａ）に示すように、左右一対の電極リード層５６及びＧＭＲ素子４５の露出した部分の上に、ＧＭＲ素子４５の露出した部分にあたるフリー磁性層４４の酸化を防止し、耐食性を向上させるために、Ｔａ等の材料でキャップ層６１を成膜する。

【００４５】次に、図６（ｂ）に示すように、それらの上に、下部ギャップ絶縁層３２と同様の絶縁材料を用いて上部ギャップ絶縁層６２を成膜し、更に、図６（ｃ）に示すように、上部ギャップ絶縁層６２の上に、下部シールド層３１と同じような軟磁性材料を用いて上部シールド層６３を成膜形成して、再生用磁気抵抗効果型薄膜磁気ヘッド６４を形成する。

【００４６】尚、ＧＭＲ素子を構成する固定磁性層或いは積層縦バイアス層を構成する強磁性膜の夫々の磁化の方向を設定する熱処理（アニール処理）は、左右一対の電極リード層５６が形成され、その上を覆うようにキャップ層６１を成膜した後、ＧＭＲ素子４５、左右一対の積層縦バイアス層５５、左右一対の電極リード層５６及びキャップ層６１を所定の形状にパターニングして削り取られる前の段階で実施するのが好ましい。即ち、第４の工程終了後、磁気記録媒体に対向するヘッド摺動面と直行するＹ方向（図６（ａ）の紙面に垂直な方向）に磁場を加えて、所定の温度で、所定時間でアニール（熱処理）して、固定磁性層４２の磁化の方向を反強磁性層４１との交換結合磁界によりＹ方向に固定する。また、固定磁性層４２の磁化の方向（Ｙ方向）に直交する方向（例えば、－Ｘ方向）に磁場を加え、固定磁性層４２の磁化の方向を設定する熱処理条件と異なる条件で熱処理（アニール）を行い、固定磁性層４２の磁化の方向に影響を与えることなく、強磁性膜５３の磁化の方向を固定磁性層４２の磁化の方向に直交させ、強磁性膜５３との交換結合磁界によりフリー磁性層４４の磁化の方向を強磁性膜５３の磁化の方向と逆方向（Ｘ方向）となるようにする。また、固定磁性層或いは積層縦バイアス層の強磁性膜の夫々の磁化の方向を設定する熱処理（アニール処理）の順序は、固定磁性層或いは強磁性膜のいずれの磁性膜を先に処理しても良い。

【００４７】尚、前述の第１の工程において、図２（ｃ）に示すように、固定磁性層を第１の固定磁性層膜２００６、第１の非磁性層膜２００７、第２の固定磁性層膜２００８を順次積層成膜して、非磁性層膜を介して複数層の固定磁性層膜を積層した積層固定磁性層２４を形成しても良い。また、図２（ｄ）に示すように、フリー磁性層も第１のフリー磁性層膜２０１１、第２のフリー磁性層膜２０１２、……、第ｎのフリー磁性層膜２０１３というように、互いに隣り合うフリー磁性層は異種の材料を用いて積層成膜し、積層フリー磁性層２５を形成しても良いということは言うまでもない。

【００４８】また、前述の第２の工程として、茸型のレジスト５１を形成した後、ＧＭＲ素子４５の最上部に成膜されたフリー磁性層４４の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、フリー磁性層４４の表面の酸化膜、レジストの残さ、異物或いは汚れ等を取り除いた後、ＧＭＲ素子４５のフリー磁性層４４の上に左右一対の非磁性膜５２を成膜する。次に、その上に、左右一対の強磁性膜５３を成膜し、更に、左右一対の強磁性膜５３の上に左右一対の反強磁性膜５４を成膜形成し、夫々左右一対の非磁性膜５２、強磁性膜５３及び反強磁性膜５４で構成される左右一対の積層縦バイアス層５５を形成することによって、積層縦バイアス層とフリー磁性層との間に異物をなくし、交換結合磁界の低下を抑止することができ、強い交換結合磁界を維持することができる。

【００４９】また、第２の工程として、図７（ａ）に示すように、ＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように、Ｒｕ等の非磁性材料を用いて非磁性層膜７０１を前述の非磁性膜の膜厚の条件を満たした膜厚で成膜し、次に、非磁性層膜７０１の上面にＧＭＲ素子４５を構成するフリー磁性層４４と同様の材料を用いて強磁性層膜７０２を成膜する。更に、強磁性層膜７０２の上面に、ＧＭＲ素子４５の反強磁性層４１と同様の材料（但し、場合によっては酸化金属膜は用いない方が良い）を用いて反強磁性層膜７０３を積層成膜する。次に、フォトレジストを塗布してドライエッチング等の方法により、図７（ｂ）に示すように、積層された非磁性層膜７０１、強磁性層膜７０２及び反強磁性層膜７０３がＧＭＲ素子４５を構成するフリー磁性層４４の上面が露出するように削除され、夫々左右一対の非磁性膜７１、強磁性膜７２及び反強磁性膜７３を形成し、夫々左右一対の非磁性膜７１、強磁性膜７２及び反強磁性膜７３で構成される左右一対の積層縦バイアス層７４を形成する。尚、ドライエッチング等の方法により、少なくとも強磁性層膜７０２及び反強磁性層膜７０３が削除され、非磁性層膜７０１が露出するようにされても良い。この場合の固定磁性層及び積層縦バイアス層を構成する強磁性膜との交換結合磁界によるフリー磁性層に磁化の方向を設定するための熱処理は、非磁性層膜７０１、強磁性層膜７０２及び反強磁性層膜７０３を順次積層成膜した後で、且つ、ドライエッチング等の方法により非磁性層膜７０１或いはフリー磁性層４４の上面が露出するように削除される前に行うのが望ましい。次に、第３の工程として、図７（ｃ）に示すように、左右一対の反強磁性膜７３及びＧＭＲ素子４５の露出した部分の上に全体を覆うように電極リード層膜７０５を成膜し、その後、フォトレジストを塗布してドライエッチング等の方法により電極リード層膜７０５を削除して、電極リード層７５を形成しても良い。また、図７（ｄ）に示すように、茸型レジスト（図示せず）を形成して、電極リード層７６を成膜形成しても良い。その他の工程は、前述の工程と同じ工程を用いて再生用磁気抵抗効果型薄膜磁気ヘッドを作製することもできる。

【００５０】また、第２の工程として、図８に示すように、ＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように、Ｒｕ等の非磁性材料を用いて非磁性膜８１を前述の非磁性膜の膜厚の条件を満たした膜厚で成膜した後、茸型レジスト８２を形成して、夫々左右一対の強磁性膜８３及び反強磁性膜８４を順次成膜形成して、非磁性膜８１、左右一対の強磁性膜８３及び左右一対の反強磁性膜８４からなる左右一対の積層縦バイアス層８５を形成しても良い。

【００５１】また、前述の第２の工程において茸型レジストを用いて左右一対の反強磁性膜５４が形成された後、第３の工程として、図９（ａ）に示すように、その茸型レジストを削除して、左右一対の反強磁性膜５４及びＧＭＲ素子４５の露出した部分の上に全体を覆うように電極リード層膜９１を成膜し、その後、図９（ｂ）に示すように、ＧＭＲ素子４５の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により電極リード層膜９１の一部を削除して、左右一対の電極リード層９２を形成しても良い。また、図９（ｃ）に示すように、上述の第２の工程の他の例でＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように成膜された非磁性膜９３の上面に成膜された夫々左右一対の反強磁性膜９４及び非磁性膜９３の露出した部分を覆うように電極リード層膜９５を成膜し、その後、フォトレジストを塗布してドライエッチング等の方法により、非磁性膜９３或いはＧＭＲ素子４５の一部が露出するように電極リード層膜９５の一部を削除して、左右一対の電極リード層９６を形成しても良い。

【００５２】また、図１０（ａ）に示すように、第３の工程として、第２の工程で形成した茸型レジストを取り除いた後、別の茸型レジストを形成して、左右一対の反強磁性膜５４及びＧＭＲ素子４５の露出した部分の一部を覆うようにして左右一対の電極リード層１０１を形成しても良い。また、図１０（ｂ）に示すように、第２の工程で形成した茸型レジストを取り除いた後、別の茸型レジストを形成して、左右一対の反強磁性膜１０３及び

ＧＭＲ素子４５の上に成膜された非磁性膜１０２の露出した部分の一部を覆うようにして左右一対の電極リード層１０４を形成しても良い。尚、図１０（ｃ）に示すように、第３の工程として、第２の工程で形成した茸型レジストを取り除いた後、反強磁性層５４及び露出したＧＭＲ素子４５の上を覆うように、Ｔａ等を材料とするキャップ層１０５を成膜し、ＧＭＲ素子４５の上にあるキャップ層の上面の一部に別の茸型レジスト（図示せず）を形成して左右一対の電極リード層１０６を形成しても良い。また、図８におけるように、ＧＭＲ素子４５の上に非磁性膜８１が成膜された後、茸型レジスト８２を形成して、夫々左右一対の強磁性膜８３及び反強磁性膜８４が形成された場合にも、図示しないが、前述と同様に、反強磁性膜及び非磁性膜の露出した部分を覆うようにキャップ層を成膜して、その上に別の茸型レジストを形成して左右一対の電極リード層を形成しても良い。

【００５３】また、前述の第２の工程及び第３の工程において、第２の工程として、図７（ａ）に示すように、ＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように、非磁性層膜７０１、強磁性層膜７０２及び反強磁性層膜７０３を順次積層成膜し、第３の工程として、図１１（ａ）に示すように、更にその上に電極リード層膜１１０１を成膜した後、図１１（ｂ）に示すように、非磁性層膜７０１或いはフリー磁性層４４の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により、少なくとも電極リード層膜１１０１、反強磁性層膜７０３及び強磁性層膜７０２を削り取って、フリー磁性層４４の上に、夫々左右一対の非磁性膜１１１、強磁性膜１１２及び反強磁性膜１１３からなる左右一対の積層縦バイアス層１１４及び左右一対の電極リード層１１５を形成しても良い。この場合にも、ＧＭＲ素子の固定磁性層及びフリー磁性層の夫々に所定の磁化の方向を付加する熱処理（アニール処理）は、非磁性層膜、強磁性層膜、反強磁性層膜および電極リード層膜が積層成膜された後、且つ、ドライエッチング等によって削除される前に実施するのが好ましい。

【００５４】以上のように本実施の形態によれば、フリー磁性層に磁化の方向を与える縦バイアス層として、夫々左右一対の非磁性膜、強磁性膜及び反強磁性膜を積層した積層縦バイアス層とした構成として、左右一対の強磁性膜の上に反強磁性膜を積層し、強磁性膜と反強磁性膜との間の交換結合磁界により、強磁性膜の磁化の方向が一定の方向（例えば、－Ｘ方向）に揃えられ、また、適当な膜厚で形成された左右一対の非磁性膜を介して、－Ｘ方向に磁化された左右一対の強磁性膜に対向しているフリー磁性層が、その対向している部分において、反強磁性膜と直接接したフリー磁性層の場合よりも、より一層強い強磁性膜との交換結合磁界によりフリー磁性層は磁化の方向（Ｘ方向）を強く保持し、一方で、左右一対の強磁性膜に対向している左右のフリー磁性層の間にあるＧＭＲ素子を構成するフリー磁性層の部分も、安定してＸ方向に向き易くなり、バルクハウゼンノイズの発生が少なく、非常に安定した再生性能を有する再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００５５】（実施の形態４）図１２～図１９は、本発明の実施の形態４を示す概要説明図であり、前述の実施の形態３と同様に、磁気記録媒体に対向するヘッド摺動面の近傍におけるヘッド摺動面と平行な面で切断した断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００５６】前述の実施の形態３と同様に、第１の工程として、図４（ａ）に示すように、下部ギャップ絶縁層３２の上に、反強磁性層４１を成膜し、更に、図４（ｂ）に示すように、その上に、固定磁性層４２を成膜する。次に、図４（ｃ）に示すように、固定磁性層４２の上に、非磁性導電層４３を成膜し、更に、図４（ｄ）に示すように、非磁性導電層４３の上に、フリー磁性層４４を成膜して、反強磁性層４１、固定磁性層４２、非磁性導電層４３及びフリー磁性層４４が薄膜で順次積層成膜されたＧＭＲ素子４５を形成する。

【００５７】次に、第２の工程として、図１２（ａ）に示すように、茸型レジスト１２１を形成して、ＧＭＲ素子４５を構成するフリー磁性層４４の上に、左右一対の第１の非磁性膜１２２を成膜する。尚、この非磁性膜１２２の膜厚は、前述の実施の形態３と同様である。更に、図１２（ｂ）に示すように、その上に、左右一対の第１の強磁性膜１２３を成膜する。更に、図１３（ａ）に示すように、左右一対の第１の強磁性膜１２３の上に、第１の非磁性膜１２２と同様の材料で第２の非磁性膜１３１を成膜する。更に、その上に、第１の強磁性膜１２３と同様の材料を用いて第２の強磁性膜１３２を成膜する。次に、図１３（ｂ）に示すように、第２の強磁性膜１３２の上に、反強磁性膜１３３を成膜形成し、夫々左右一対の第１の非磁性膜１２２、第１の強磁性膜１２３、第２の非磁性膜１３１、第２の強磁性膜１３２及び反強磁性膜１３３で構成される左右一対の積層縦バイアス層１３４を形成する。

【００５８】第３の工程として、図１４（ａ）に示すように、実施の形態３と同様にして、左右一対の反強磁性膜１３３の上に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて左右一対の電極リード層１４１を成膜する。

【００５９】第４の工程として、図１４（ｂ）に示すように、左右一対の電極リード層１４１及びＧＭＲ素子４５の露出した部分の上に、ＧＭＲ素子４５の露出した部分にあたるフリー磁性層４４の酸化を防止し、耐食性を向上させるために、Ｔａ等の材料でキャップ層１４２を成膜する。

【００６０】尚、反強磁性膜１３３として用いる材料は前述の実施の形態３と同じような条件で選定しなければならない。キャップ層１４２を形成後、前述の実施の形

態３と同じようにして、固定磁性層４２の磁化の方向（Ｙ方向）及びフリー磁性層４４の磁化の方向を固定磁性層４２の磁化の方向（Ｙ方向）に直交する方向（例えば、－Ｘ方向）に設定するために、夫々の方向に磁場を与えて、夫々所定の温度及び所定の時間で熱処理（アニール）を行い、固定磁性層及び積層縦バイアス層とフリー磁性層に所定の磁化の方向を与える。

【００６１】また、第２の工程として、茸型レジストを形成した後、ＧＭＲ素子４５の最上部に成膜されたフリー磁性層４４の上面をＡｒ等によるプリスパッタ或いはＥＣＲ等の方法によってクリーニングし、フリー磁性層４４の表面の酸化膜、レジストの残さ、異物或いは汚れ等を取り除いた後、図１３（ｂ）に示すように、フリー磁性層４４の上に、左右一対の第１の非磁性膜１２２を成膜し、その上に左右一対の第１の強磁性膜１２３を成膜する。次に、その上に第２の非磁性膜１３１を成膜し、その上に第２の強磁性膜１３２を成膜する。更に、左右一対の反強磁性膜１３３を成膜形成し、夫々左右一対の第１の非磁性膜１２２、第１の強磁性膜１２３、第２の非磁性膜１３１、第２の強磁性膜１３２及び反強磁性膜１３３で構成される左右一対の積層縦バイアス層１３４を形成することにより、左右一対の積層縦バイアス層とフリー磁性層との強い交換結合磁界が得られる。

【００６２】また、第２の工程として、図１５（ａ）に示すように、ＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように、第１の非磁性層膜１５０１、第１の強磁性層膜１５０２、第２の非磁性層膜１５０３、第２の強磁性層膜１５０４及び反強磁性層膜１５０５を順次積層成膜した後、図１５（ｂ）に示すように、フォトレジストを塗布してドライエッチング等の方法により、第１の非磁性層膜１５０１或いはＧＭＲ素子４５を構成するフリー磁性層４４の上面が露出するように、少なくとも積層された第１の強磁性層膜１５０２、第２の非磁性層膜１５０３、第２の強磁性層膜１５０４及び反強磁性層膜１５０５が削除され、夫々左右一対の第１の非磁性膜１５１、第１の強磁性膜１５２、第２の非磁性膜１５３、第２の強磁性膜１５４及び反強磁性膜１５５を形成し、夫々左右一対の第１の非磁性膜１５１、第１の強磁性膜１５２、第２の非磁性膜１５３、第２の強磁性膜１５４及び反強磁性膜１５５で構成される左右一対の積層縦バイアス層１５６を形成しても良い。この場合にも、固定磁性層或いは積層縦バイアス層の強磁性膜の夫々の磁化の方向を設定する熱処理（アニール処理）は、第１の非磁性層膜１５０１、第１の強磁性層膜１５０２、第２の非磁性層膜１５０３、第２の強磁性層膜１５０４及び反強磁性層膜１５０５を順次積層成膜した後で、且つ、積層された第１の非磁性層膜１５０１、第１の強磁性層膜１５０２、第２の非磁性層膜１５０３、第２の強磁性層膜１５０４及び反強磁性層膜１５０５がドライエッチング等の方法により削除される前に実施するのが好ましい。

【００６３】また、図１６に示すように、第２の工程として、ＧＭＲ素子を構成するフリー磁性層４４の上面を覆うように、第１の非磁性膜１６１を成膜した後、茸型レジスト１６２を形成して、夫々左右一対の第１の強磁性膜１６３、第２の非磁性膜１６４、第２の強磁性膜１６５及び反強磁性膜１６６を順次成膜形成して、第１の非磁性膜１６１、左右一対の第１の強磁性膜１６３、第２の非磁性膜１６４、第２の強磁性膜１６５及び左右一対の反強磁性膜１６６からなる左右一対の積層縦バイアス層１６７を形成しても良い。

【００６４】また、前述の実施の形態３における他の一例と同様にして、第３の工程として、図１７（ａ）に示すように、茸型レジストを削除して、左右一対の反強磁性膜１３３及びＧＭＲ素子を構成するフリー磁性層４４の露出した部分の上に全体を覆うように電極リード層膜１７１を成膜し、その後、フォトレジストを塗布してドライエッチング等の方法により、電極リード層膜１７１の一部を削除してフリー磁性層４４の一部の上面が露出するようにし、左右一対の電極リード層１７２を形成しても良い。また、図１７（ｂ）に示すように、他の例における第２の工程でＧＭＲ素子４５を構成するフリー磁性層４４の上面を覆うように成膜された第１の非磁性膜１６１の露出した部分の上面及び反強磁性膜１６６の上を覆うように、電極リード層膜１７３を成膜し、その後、フォトレジストを塗布してドライエッチング等の方法により、第１の非磁性膜１６１或いはフリー磁性層４４の一部が露出するように電極リード層膜１７３の一部を削除して、左右一対の電極リード層１７４を形成しても良い。

【００６５】また、第３の工程として、図１８（ａ）に示すように、第２の工程で形成した茸型レジストを削除し、別の茸型レジスト１８１を形成して、左右一対の反強磁性膜１３３及びＧＭＲ素子を構成するフリー磁性層４４の露出した部分の一部を覆うようにして左右一対の電極リード層１８２を形成しても良い。また、図１８（ｂ）に示すように、第２の工程で形成した茸型レジストを削除し、別の茸型レジスト１８３を形成して、左右一対の反強磁性膜１６６及びフリー磁性層４４の上に成膜された第１の非磁性膜１６１の露出した部分の一部を覆うようにして左右一対の電極リード層１８４を形成しても良い。尚、図示していないが、前述の実施の形態３における第３の工程の他の例において説明したように、別の茸型レジスト１８１を形成する前に、左右一対の反強磁性膜１３３及びＧＭＲ素子を構成するフリー磁性層４４の露出した部分を覆うようにキャップ層を成膜して後、別の茸型レジスト１８１を形成して、左右一対の電極リード層１８２を形成しても良い。また、別の茸型レジスト１８３を形成する前に、左右一対の反強磁性膜１６６及びフリー磁性層４４の上に成膜された第１の非磁

性膜１６１の露出した部分の上を覆うように、キャップ層を成膜して後、別の茸型レジスト１８３を形成して、左右一対の電極リード層１８４を形成しても良い。

【００６６】また、前述の第２の工程及び第３の工程において、第２の工程として、図１９に示すように、ＧＭＲ素子を構成するフリー磁性層４４の上面を覆うように、第１の非磁性層膜１９０１、第１の強磁性層膜１９０２、第２の非磁性層膜１９０３、第２の強磁性層膜１９０４及び反強磁性層膜１９０５を順次積層成膜し、次に、第３の工程として、更にその上に電極リード層膜１９０６を成膜した後、フリー磁性層４４の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により、電極リード層膜１９０６、反強磁性層膜１９０５、第２の強磁性層膜１９０４、第２の非磁性膜１９０３、第１の強磁性膜１９０２及び第１の非磁性層膜１９０１を削り取って、フリー磁性層４４の上に、夫々左右一対の第１の非磁性膜１９１、第１の強磁性膜１９２、第２の非磁性膜１９３、第２の強磁性膜１９４及び反強磁性膜１９５からなる左右一対の積層縦バイアス層１９６及び左右一対の電極リード層１９７を形成しても良い。尚、この時、第１の非磁性層膜１９０１が露出するように、ドライエッチング等の方法により削り取っても良い。この場合にも、固定磁性層或いは積層縦バイアス層の強磁性膜の夫々の磁化の方向を設定する熱処理（アニール処理）は、第１の非磁性層膜１９０１、第１の強磁性層膜１９０２、第２の非磁性層膜１９０３、第２の強磁性層膜１９０４、反強磁性層膜１９０５及び電極リード層膜を順次積層成膜した後で、且つ、フォトレジストを塗布してドライエッチング等の方法によりフリー磁性層４４の一部が露出するように削除される前に行うのが好ましい。

【００６７】以上のように本実施の形態によれば、前述の実施の形態３と同様の効果が得られると同時に、積層縦バイアス層の第２の非磁性膜の膜厚を適当に選び、第１の強磁性膜と第２の強磁性膜の磁化の方向をお互いに逆向きの方向にすることによって、強磁性膜の端面磁荷による漏れ磁界を第１の強磁性膜と第２の強磁性膜でお互いに打ち消し合うことになり、且つ、強磁性膜の端面における反磁界による磁化の方向がＹ方向に傾くのを防ぎ、強磁性膜の磁化も端部まで揃うことになり、フリー磁性層の磁化の方向がより安定したものとなり、より一層安定した再生性能を有する再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００６８】（実施の形態５）図２０～図２２は、本発明の実施の形態５を示す概略説明図であり、再生用磁気抵抗効果型薄膜磁気ヘッドの製造工程を説明するための工程概要説明図であり、磁気記録媒体に対向するヘッド摺動面の近傍におけるヘッド摺動面と平行な面で切断した断面図である。以下、図面を用いて再生用磁気抵抗効果型薄膜磁気ヘッドの製造方法を各工程順に説明する。

【００６９】第１の工程として、図２０（ａ）に示すように、反強磁性層２０１、固定磁性層２０２、非磁性導電層２０３及びフリー磁性層２０４が積層成膜されて形成されたＧＭＲ素子２０５の上に、Ｔａ等の材料を用いてフリー磁性層２０４の酸化防止のためのキャップ層２０６を成膜する。

【００７０】次に、第２の工程として、図２０（ｂ）に示すように、茸型のレジスト２０７を形成して、ＧＭＲ素子２０５のフリー磁性層２０４の両側部の一部が露出するように、キャップ層２０６の一部を削除し、その上に、夫々左右一対の非磁性膜２０５１、強磁性膜２０５２及び反強磁性膜２０５３を順次積層成膜して、左右一対の積層縦バイアス層２０８を形成する。

【００７１】第３の工程として、図２０（ｃ）に示すように、左右一対の反強磁性膜２０５３の上に、Ｃｕ、Ｃｒ或いはＴａ等の非磁性材料を用いて左右一対の電極リード層２０９を成膜する。この様にして、再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００７２】また、前述の第２の工程において、図２１に示すように、茸型レジスト２１０を形成して、ＧＭＲ素子のフリー磁性層２０４の両側部の一部が露出するように、キャップ層２０６の一部を削除し、その上に、夫々左右一対の第１の非磁性膜２１１、第１の強磁性膜２１２、第２の非磁性膜２１３、第２の強磁性膜２１４及び反強磁性膜２１５を形成して、左右一対の積層縦バイアス層２１６を形成しても良い。

【００７３】また、第１の工程において成膜される固定磁性層は、図２（ｃ）に示されるような、非磁性層を介して対向する固定磁性層からなる積層固定磁性層であっても良い。また、同様に、図２（ｄ）に示すように、フリー磁性層も隣り合うフリー磁性層が異種の軟磁性材料を用いた複数層からなる積層フリー磁性層であっても良い。

【００７４】また、第３の工程として、図２２（ａ）に示すように、茸型レジストを削除して、左右一対の反強磁性膜２０５３及びＧＭＲ素子を構成するフリー磁性層２０４の上に形成されたキャップ層２０６の露出した部分の上に全体を覆うように電極リード層膜２２１を成膜し、その後、フリー磁性層２０４の上にあるキャップ層２０６の一部が露出するように、フォトレジストを塗布してドライエッチング等の方法により電極リード層膜２２１の一部を削除して、左右一対の電極リード層２２２を形成しても良い。

【００７５】また、図２２（ｂ）に示すように、第３の工程として、第２の工程で形成した茸型レジストを取り除いた後、別の茸型レジスト２２３を形成して、左右一対の反強磁性膜２０５３及びＧＭＲ素子を構成するフリー磁性層２０４の上に形成されたキャップ層２０６の露出した部分の一部を覆うようにして左右一対の電極リード層２２４を形成しても良い。第１の非磁性膜、第１の

強磁性膜、第２の非磁性膜、第２の強磁性膜及び反強磁性膜からなる５層で積層された積層縦バイアス層の場合にも、同じようにして左右一対の電極リード層を形成することができる。

【００７６】以上のように本実施の形態によれば、前述の実施の形態３及び実施の形態４と同じような効果が得られ、フリー磁性層の磁化の方向がより安定したものとなり、より一層安定した再生性能を有する再生用磁気抵抗効果型薄膜磁気ヘッドを作製することができる。

【００７７】

【発明の効果】以上のように本発明は、ＧＭＲ素子を構成するフリー磁性層の上に、非磁性膜と強磁性膜との１回の積層或いは２回の積層と更にその上に成膜された反強磁性膜との３層或いは５層の積層縦バイアス層を形成することによって、積層縦バイアス層の強磁性膜は、その上にある反強磁性層との交換結合磁界によって一定の方向に揃えられた磁化の方向が付加され、且つ、積層縦バイアス層の適当な膜厚を有する非磁性膜を介して対向した強磁性膜とＧＭＲ素子のフリー磁性層（３層の場合）或いは適当な膜厚を有する第２の非磁性膜を介して第２の強磁性膜に対向した第１の強磁性膜と適当な膜厚を有する第１の非磁性膜を介して対向したフリー磁性層（５層の場合）との交換結合磁界は、直接反強磁性膜に接したフリー磁性層の場合に比較して、非常に強い結合磁界が得られ、非磁性膜を介して強磁性膜に対向した部分のフリー磁性層は非常に安定した磁化の方向が与えられ、非磁性膜を介して強磁性膜に対向した左右のフリー磁性層の間にあるフリー磁性層部分も、強磁性膜に対向した左右のフリー磁性層の磁化の方向と同じ方向に安定して向き易くなり、ノイズの発生が小さく、再生感度の高い、良好な再生性能を実現することができるという効果があり、特に、高記録密度化された記録信号を再生するための狭再生ヘッドギャップレングスを有する薄膜磁気ヘッドには非常に有効である。また、そのような優れた再生性能の薄膜磁気ヘッドを容易に作製することができる。

【図面の簡単な説明】

【図１】本発明の実施の形態１を示す薄膜磁気ヘッドの正面概略模式図

【図２】本発明の実施の形態２を示す薄膜磁気ヘッドの正面概略模式図

【図３】本発明の実施の形態３における薄膜磁気ヘッドの製造工程の一部を示す正面概略図

【図４】本発明の実施の形態３における薄膜磁気ヘッドの製造工程の第１の工程を示す正面概略図

【図５】本発明の実施の形態３における薄膜磁気ヘッドの製造工程の第２の工程及び第３の工程を示す正面概略図

【図６】本発明の実施の形態３における薄膜磁気ヘッドの製造工程の第４の工程及び他の一部の工程を示す正面概略図

【図７】本発明の実施の形態３の他の例における薄膜磁気ヘッドの製造工程の第２の工程及び第３の工程を示す正面概略図

【図８】本発明の実施の形態３の他の例における薄膜磁気ヘッドの製造工程の第２の工程を示す正面概略図

【図９】本発明の実施の形態３の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図１０】本発明の実施の形態３の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図１１】本発明の実施の形態３の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図１２】本発明の実施の形態４における薄膜磁気ヘッドの製造工程の第２の工程の一部を示す正面概略図

【図１３】本発明の実施の形態４における薄膜磁気ヘッドの製造工程の第２の工程の他の一部を示す正面概略図

【図１４】本発明の実施の形態４における薄膜磁気ヘッドの製造工程の第３の工程及び第４の工程を示す正面概略図

【図１５】本発明の実施の形態４の他の例における薄膜磁気ヘッドの製造工程の第２の工程を示す正面概略図

【図１６】本発明の実施の形態４の他の例における薄膜磁気ヘッドの製造工程の第２の工程を示す正面概略図

【図１７】本発明の実施の形態４の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図１８】本発明の実施の形態４の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図１９】本発明の実施の形態４の他の例における薄膜磁気ヘッドの製造工程の第２の工程を示す正面概略図

【図２０】本発明の実施の形態５における薄膜磁気ヘッドの製造工程の第１の工程、第２の工程及び第３の工程を示す正面概略図

【図２１】本発明の実施の形態５の他の例における薄膜磁気ヘッドの製造工程の第２の工程を示す正面概略図

【図２２】本発明の実施の形態５の他の例における薄膜磁気ヘッドの製造工程の第３の工程を示す正面概略図

【図２３】従来の薄膜磁気ヘッドを示す斜視概略図

【図２４】従来の薄膜磁気ヘッドを示す正面概略模式図

【符号の説明】

１、４１、２０１、２４４　反強磁性層

２、４２、２０２、２４５　固定磁性層

３、４３、２０３、２４６　非磁性導電層

４、４４、２０４、２４７　フリー磁性

５、４５、２０５、２３３　磁気抵抗効果素子（ＧＭＲ素子）

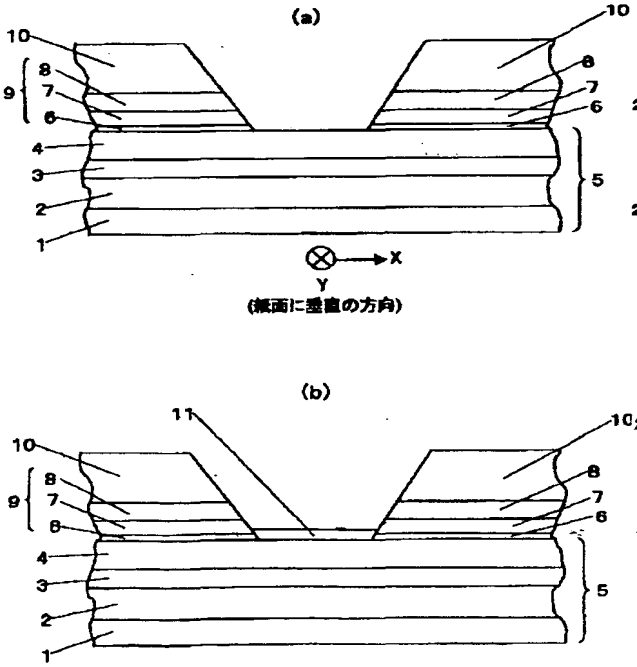
６、５２、７１、８１、９３、１０２、１１１、２０５１　非磁性膜

７、５３、７２、８３、１１２、２０５２　強磁性膜

８、５４、７３、８４、９４、１０３、１１３、１３３、１５５、１６６、１９５、２１５、２００５、２０

５３　反強磁性膜
９、２１、５５、７４、８５、１１４、１３４、１５６、１６７、１９７、２０８、２１６　積層縦バイアス層
１０、２２、５６、７５、７６、９２、９６、１０１、１０４、１０６、１１５、１４１、１７２、１７４、１８２、１８４、２０９、２２２、２２４、２３５　電極リード層
１１、２３、６１、１０５、１４２、２０６、２４８　キャップ層
２４　積層固定磁性層
２５　積層フリー磁性層
３０　基板
３１、２３１　下部シールド層
３２、２３２　下部ギャップ絶縁層
５１、８２、１２１、１６２、１８１、１８３、２０７、２１０、２２３　茸型レジスト
６２、２３６　上部ギャップ絶縁層
６３、２３７　上部シールド層
６４、２３８　再生用磁気抵抗効果型薄膜磁気ヘッド
９１、９５、１７１、１７３、２２１、７０５、１１０１、１９０６　電極リード層膜
１２２、１５１、１６１、１９１、２１１、２００１　第１の非磁性膜
１２３、１５２、１６３、１９２、２１２、２００２　第１の強磁性膜
１３１、１５３、１６４、１９３、２１３、２００３　第２の非磁性膜
１３２、１５４、１６５、１９４、２１４、２００４　第２の強磁性膜
２３４　縦バイアス層
２４０　記録用誘導型薄膜磁気ヘッド
２４１　記録ギャップ層
２４２　上部磁極
２４３　巻線コイル
２４９　再生ヘッドギャップレングス
７０１　非磁性層膜
７０２　強磁性層膜
７０３、１５０５、１９０５　反強磁性層膜
１５０１、１９０１、２００７　第１の非磁性層膜
１５０２、１９０２　第１の強磁性層膜
１５０３、１９０３　第２の非磁性層膜
１５０４、１９０４　第２の強磁性層膜
２００６　第１の固定磁性層膜
２００８　第２の固定磁性層膜
２０１１　第１のフリー磁性層膜
２０１２　第２のフリー磁性層膜
２０１３　第ｎのフリー磁性層膜

【図１】



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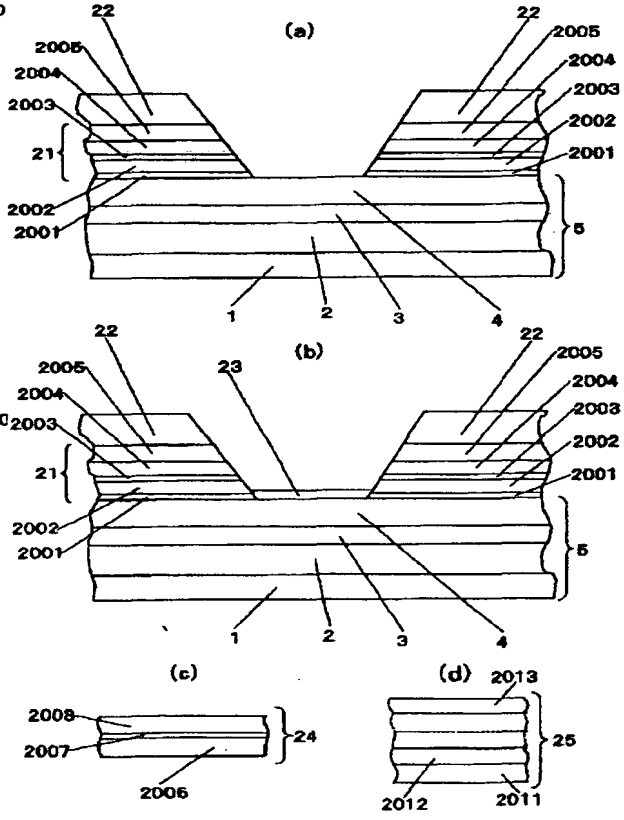

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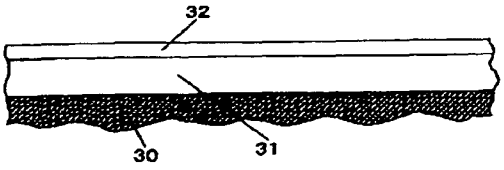

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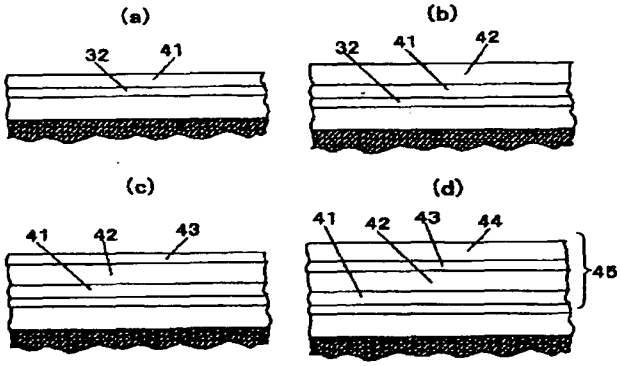

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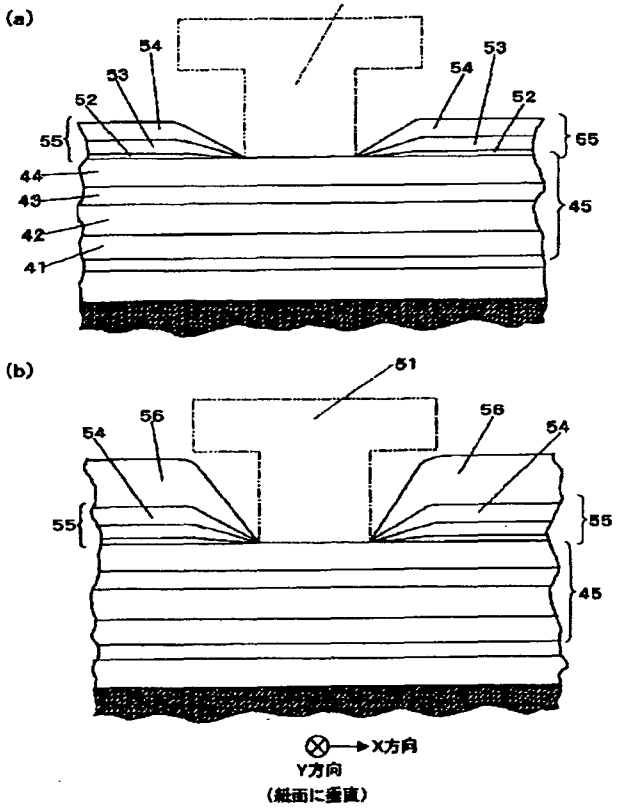

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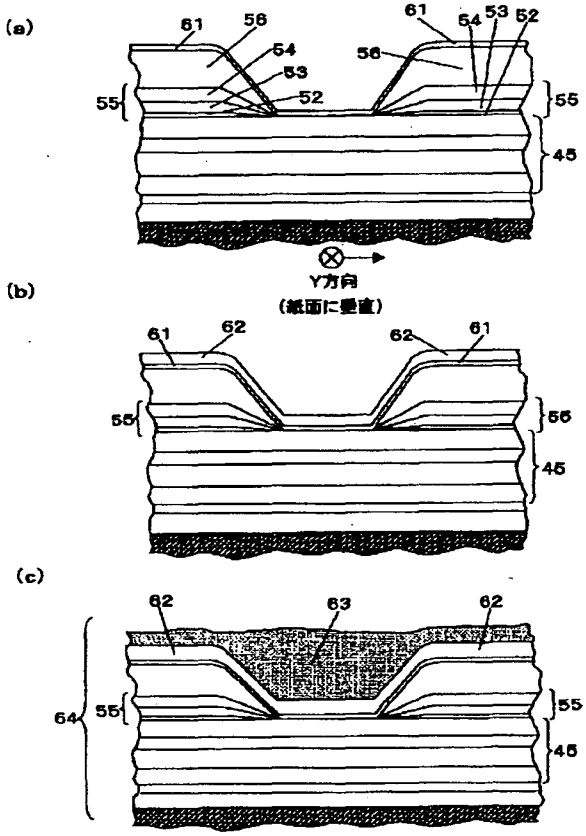

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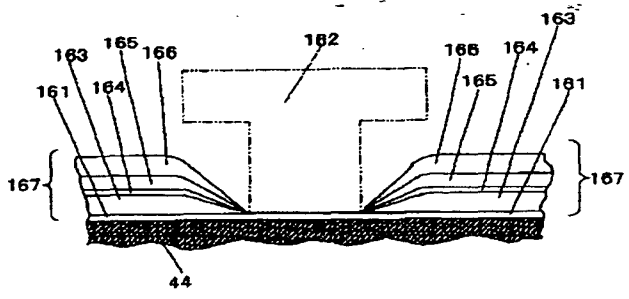

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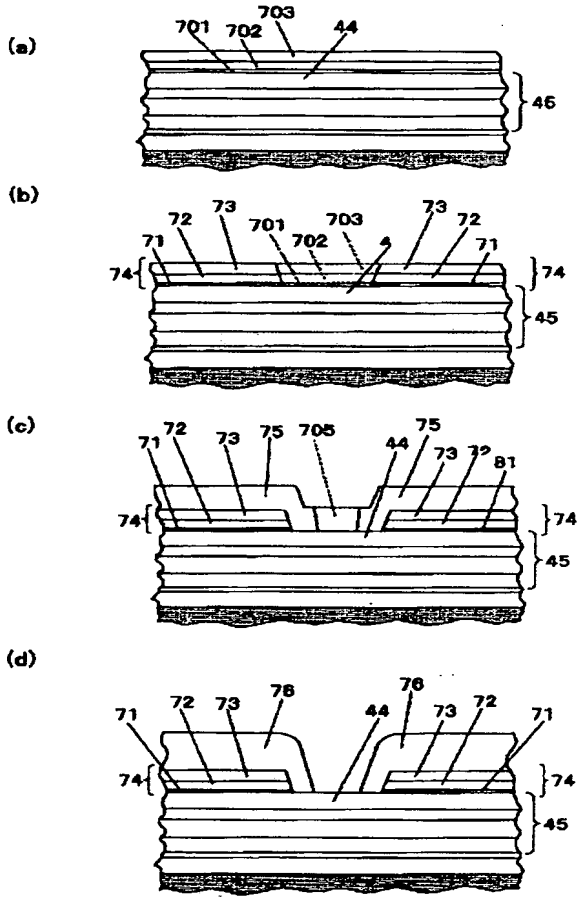
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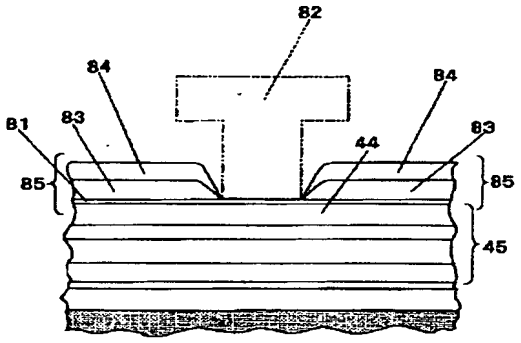
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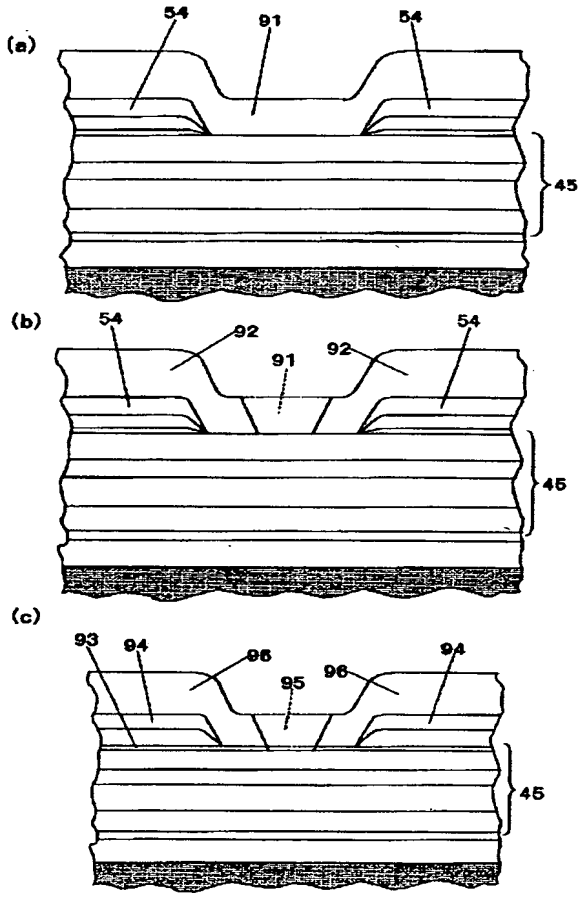
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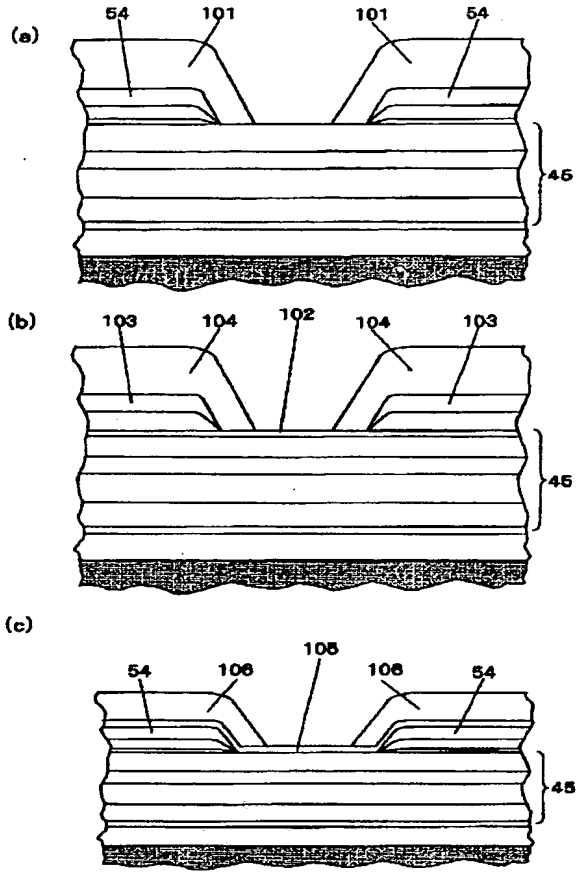
【図１０】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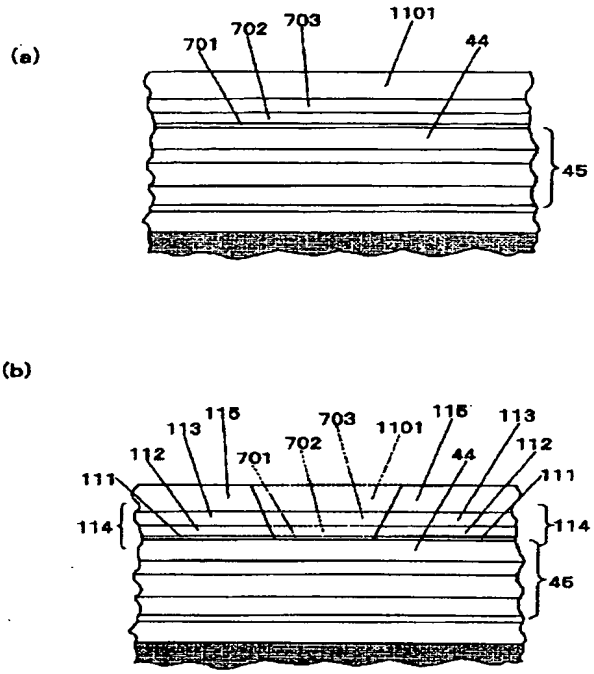
【図１１】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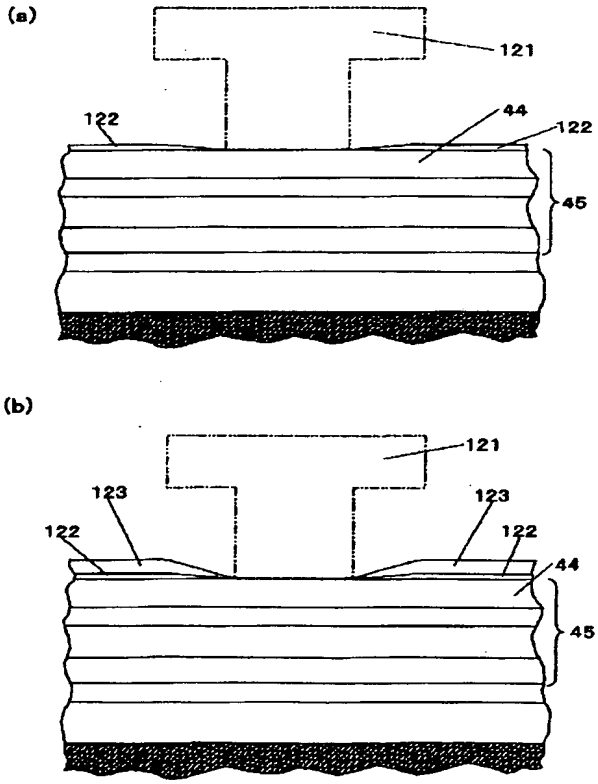
【図１２】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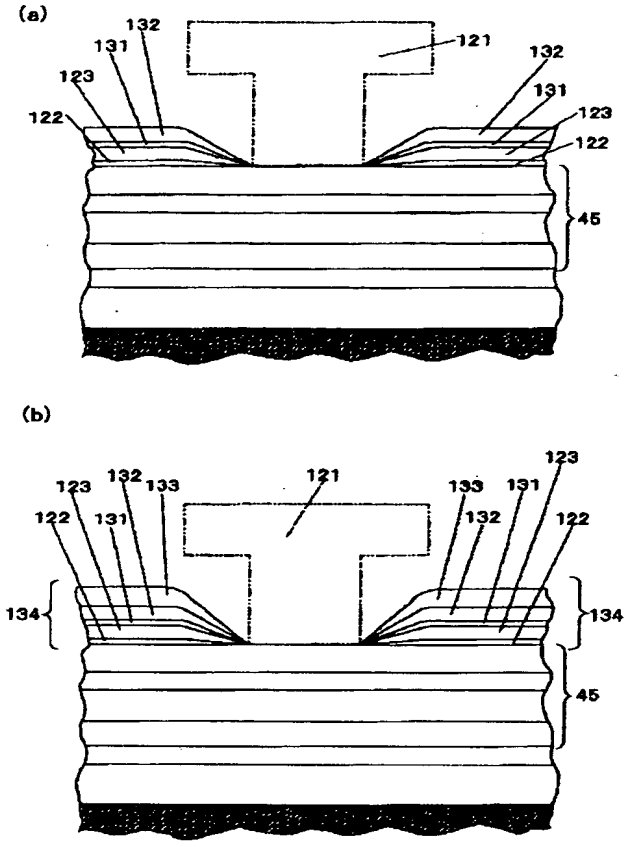
【図１３】



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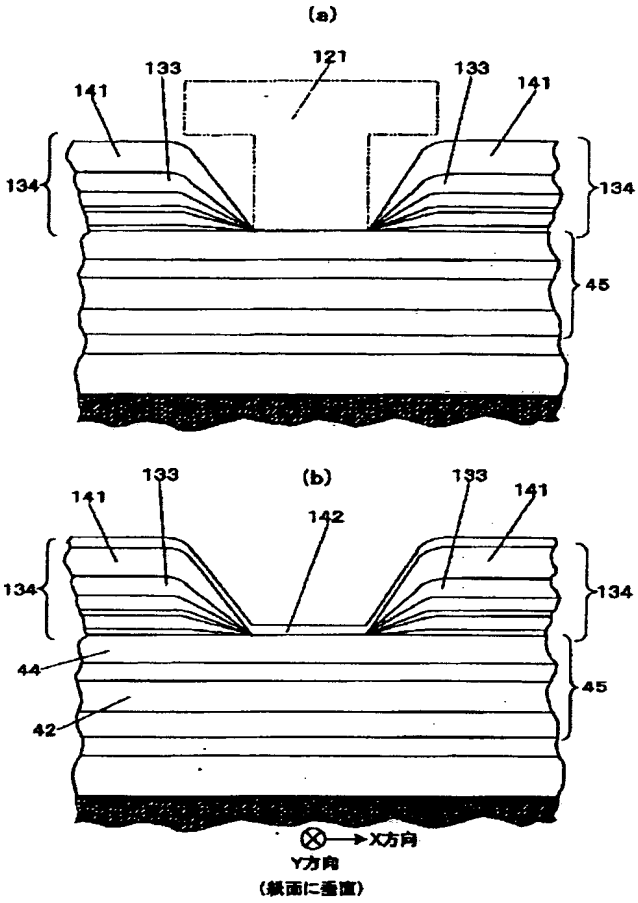

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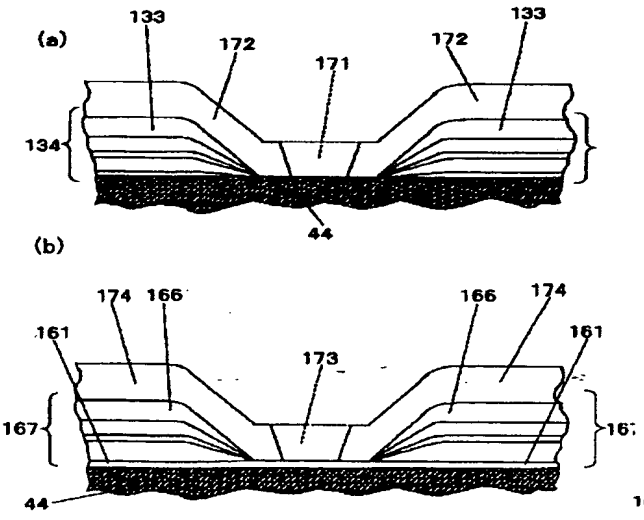

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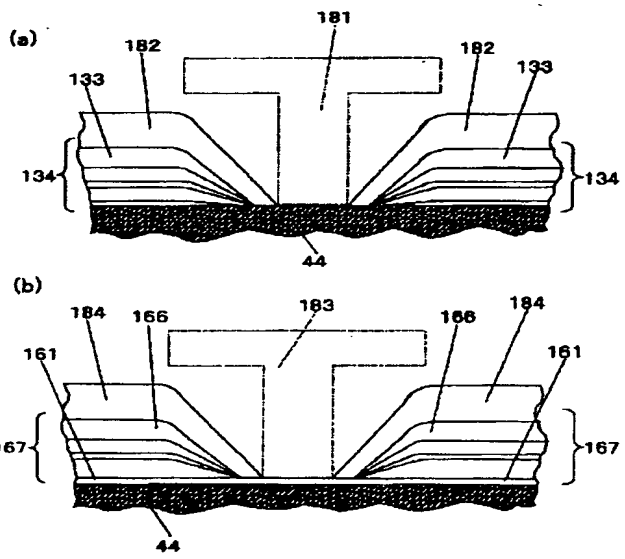

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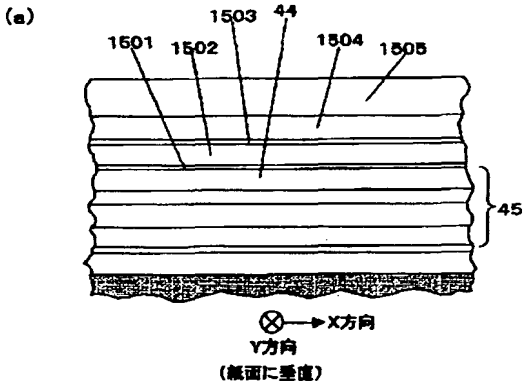

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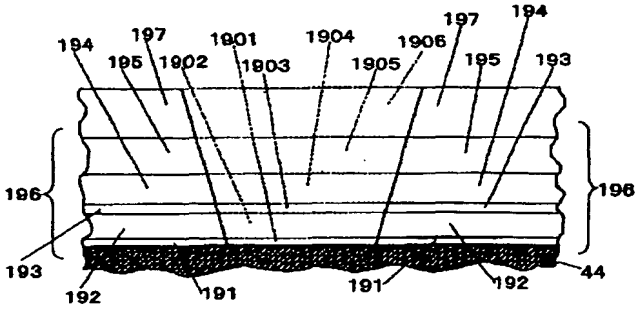

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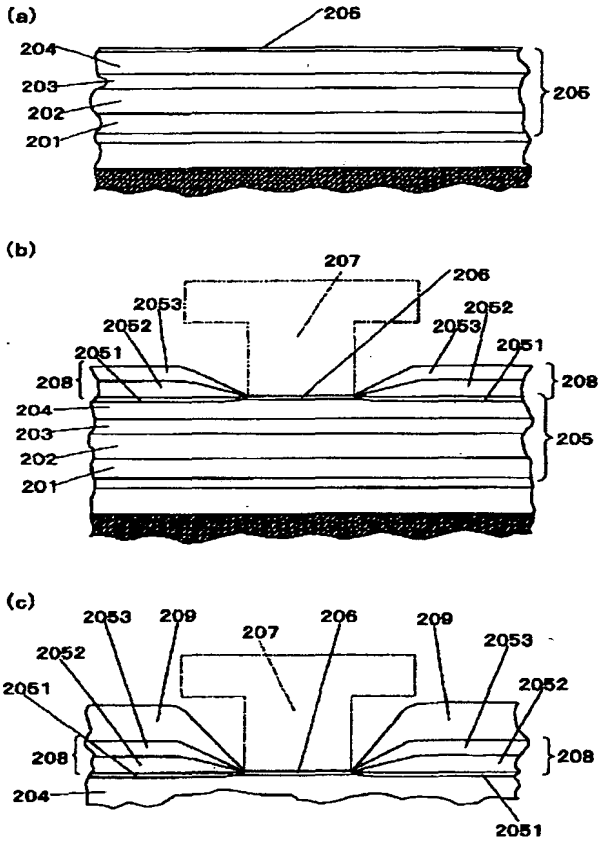
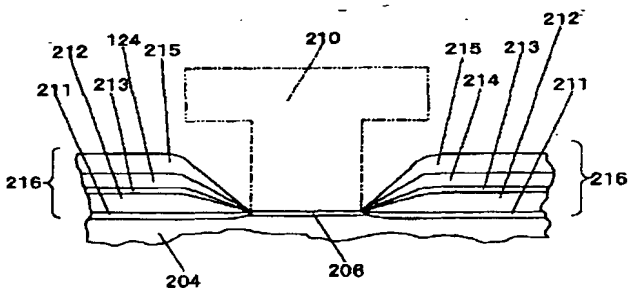


【図２１】



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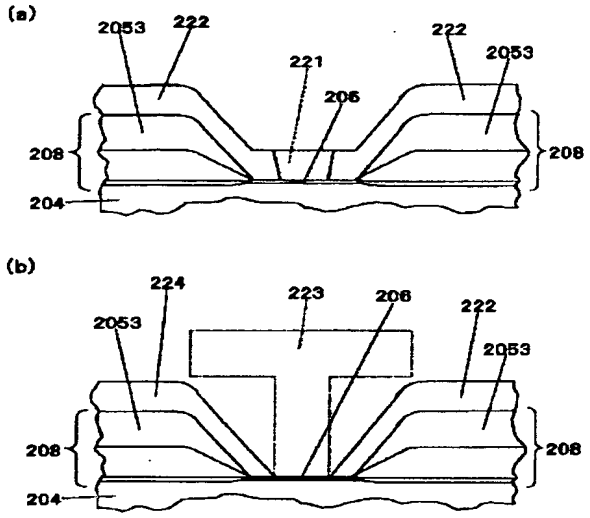

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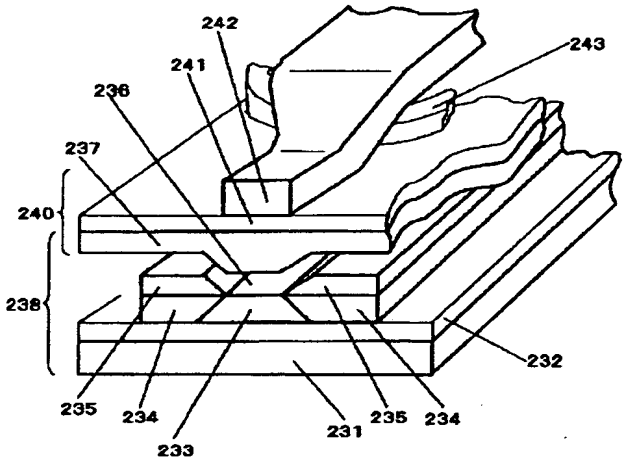

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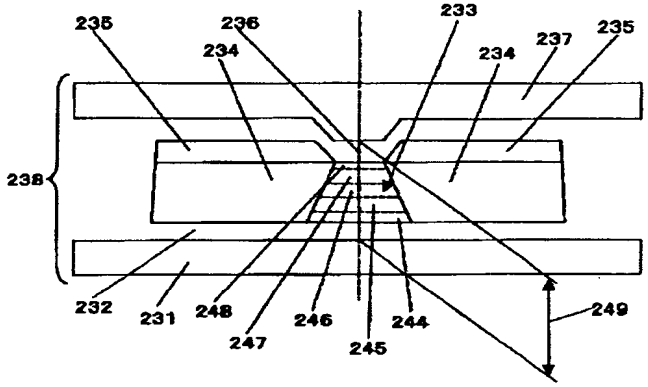

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DB02 DB12

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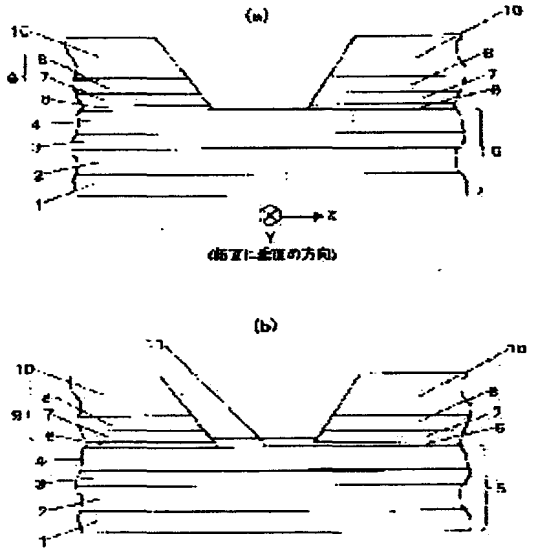
H01F 10/12
H01L 43/08
H01L 43/12

(21)Application number : 11-333776
(22)Date of filing : 25.11.1999

(71)Applicant : MATSUSHITA ELECTRIC IND CO LTD
(72)Inventor : SAKAGUCHI MASAYA
FUKAZAWA TOSHIO

(54) THIN FILM MAGNETIC HEAD AND ITS MANUFACTURING METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a thin film magnetic head, which is used as a reproducing head made to narrow the gap length for reproducing a recording signal having a short wavelength according to high-density recording, having high sensitivity and stable reproducing performance by supplying stable vertical bias and to provide a method for manufacturing the thin film magnetic head.
SOLUTION: This thin film magnetic head is obtained by forming a pair of right-and-left laminated vertical bias layers, which are constituted of a pair of right-and-left nonmagnetic films, a pair or right-and-left ferromagnetic films and a pair of right-and-left antiferromagnetic films, on a free magnetic layer existing on the uppermost part of a magneto-resistive effect element to fix the magnetization of the free magnetic layer opposite to the laminated vertical bias layers in a very strong exchange/combination magnetic field and the thin film magnetic head having high sensitivity and stable reproducing performance can be obtained.



LEGAL STATUS

[Date of request for examination]

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[Patent number]

[Date of registration]

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[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The vertical bias layer which has a magnetoresistance-effect element through an insulating material, and was prepared in contact with the aforementioned magnetoresistance-effect element between the lower shield layer and the up shield layer, In the magnetoresistance-effect type thin film magnetic head which consists of an electrode lead layer for passing the signal current The magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, the laminating length bias layer of a right-and-left couple which consists of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple on the aforementioned free magnetic layer which constitutes the aforementioned magnetoresistance-effect element, respectively, and the thin film magnetic head characterized by being come out and constituted
[Claim 2] The thin film magnetic head according to claim 1 characterized by to have the thickness of the aforementioned nonmagnetic membrane of the right-and-left couple which constitutes the aforementioned laminating length bias layer from which the direction of magnetization of the aforementioned free magnetic layer which constitutes the aforementioned magnetoresistance-effect element of the portion which has countered the aforementioned ferromagnetic of a right-and-left couple through the aforementioned nonmagnetic membrane of a right-and-left couple turns into the direction and the opposite direction of magnetization of the aforementioned ferromagnetic of a right-and-left couple.
[Claim 3] The thin film magnetic head according to claim 1 characterized by being in the range whose thickness of the aforementioned nonmagnetic membrane of a right-and-left couple is 0.4-3nm.
[Claim 4] the laminating length bias layer of a right-and-left couple which consists of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left c uple, respectively on the aforementioned free magnetic layer which constitutes the magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, and the aforementioned magnetoresistance-effect element, and the thin film magnetic head characterized by being come out and constituted
[Claim 5] It has the thickness of the 1st nonmagnetic membrane of the above of a right-and-left couple from which the direction of magnetization of the aforementioned free magnetic layer turns into the direction and opposite direction of magnetization of the 1st ferromagnetic of the above of a right-and-left couple. The thin film magnetic head according to claim 4 characterized by having the thickness of the 2nd nonmagnetic membrane of the above of a right-and-left couple from which the direction of magnetization of the 2nd ferromagnetic of the above of a right-and-left couple turns into the magnetization direction and opposite direction of a ferromagnetic layer of the above 1st of a right-and-left couple.
[Claim 6] The thin film magnetic head according to claim 4 characterized by for the thickness of the 1st nonmagnetic membrane of the above of a right-and-left couple being in the range of 0.4-3nm, and being in the range whose thickness of the 2nd nonmagnetic membrane of the above of a right-and-left couple is 0.4-3nm.
[Claim 7] The thin film magnetic head according to claim 1 to 6 characterized by having the cap layer which is between the aforementioned laminating length bias layers of a right-and-left couple, and touched the upper surface of the af rementioned magnetoresistance-effect element.
[Claim 8] The thin film magnetic head according to claim 1 to 7 characterized by consisting of laminating fixed magnetic layers to which the aforementioned fixed magnetic layer which constitutes the aforementioned magnetoresistance-effect element carried out the laminating of the two fixed magnetic layer films which counter through a non-magnetic layer film.
[Claim 9] The thin film magnetic head according to claim 8 characterized by having the thickness of the aforementioned non-magnetic layer film which becomes each other in the reverse direction in the aforementioned laminating fixed magnetic layer about the direction of magnetization of the aforementioned fixed magnetic layer film which countered through the aforementioned non-magnetic layer film.
[Claim 10] The thin film magnetic head according to claim 8 to which thickness of the aforementioned non-magnetic layer film is characterized by being in the range of 0.4-3nm in the aforementioned laminating fixed magnetic layer.
[Claim 11] The thin film magnetic head according to claim 1 to 10 characterized by the aforementioned free magnetic layer which constitutes the aforementioned magnetoresistance-effect element consisting of laminating free magnetic layers by which two or more layer laminating was carried out by soft magnetic materials of a different kind in the material of the adjacent free magnetic layer film.
[Claim 12] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element in the upper surface of the lower gap insulating layer formed on the lower shield layer. On the aforemention d free magnetic layer at the topmost part of the aforementioned magnetoresistance-effect element, carry out membrane formation formation of the nonmagnetic membrane of a right-and-left couple, carry out laminating membrane formation of the ferromagnetic of a right-and-left couple on it, and laminating membrane formation of the antiferromagnetism film of a right-and-left couple is carried out further at a it top. The 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of the aforementioned nonmagnetic membrane, the aforementioned ferromagnetic, and the aforementioned antiferromagnetism film, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the aforementioned antiferromagnetism film formed in the topmost part of the

aforementioned laminating length bias layer.
[Claim 13] The manufacture method of the thin film magnetic head according to claim 12 characterized by having the 2nd process which carries out laminating membrane formation of the nonmagnetic membrane of a right-and-left couple, the ferromagnetic of a right-and-left couple, and the antiferromagnetism film of a right-and-left couple, and forms the laminating length bias layer of a right-and-left couple on the aforementioned free magnetic layer after cleaning the aforementioned free magnetic layer formed in the topmost part of the aforementioned magnetoresistance-effect element in the 2nd process of a claim 12.
[Claim 14] So that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered in the 2nd process of a claim 12 So that a part of aforementioned free magnetic layer formed in a part of aforementioned nonmagnetic membrane or the topmost part of the aforementioned magnetoresistance-effect element may be exposed, after carrying out laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one By deleting a part of aforementioned ferromagnetic layer membrane by which laminating membrane formation was carried out at least, and aforementioned antiferromagnetism layer membrane, and forming the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple on the aforementioned free magnetic layer, respectively The manufacture method of the thin film magnetic head according to claim 12 characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple.
[Claim 15] After forming a nonmagnetic membrane so that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered in the 2nd process of a claim 12, laminating membrane formation formation of the ferromagnetic and antiferromagnetism film of a right-and-left couple is carried out one by one on it, respectively. The manufacture method of the thin film magnetic head according to claim 12 characterized by having the 2nd process which forms the vertical bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic of a right-and-left couple, and an antiferromagnetism film of a right-and-left couple.
[Claim 16] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer one by one, and forms a magnetoresistance-effect element in the upper surface of the lower gap insulating layer formed on the lower shield layer. On the aforementioned free magnetic layer formed in the topmost part of the aforementioned magnetoresistance-effect element, laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. The 2nd process which forms the laminating length bias layer of a right-and-left couple, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the aforementioned antiferromagnetism film formed in the topmost part of the aforementioned laminating length bias layer.
[Claim 17] After cleaning the aforementioned free magnetic layer formed in the topmost part of the aforementioned magnetoresistance-effect element in the 2nd process of a claim 16, On the aforementioned free magnetic layer, laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. The manufacture method of the thin film magnetic head according to claim 16 characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple.
[Claim 18] So that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered in the 2nd process of a claim 16 After carrying out laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one, So that a part of aforementioned free magnetic layer formed in some non-magnetic layer films of the above 1st or the topmost part of the aforementioned magnetoresistance-effect element may be exposed A part of the ferromagnetic layer membrane of the above 1st by which laminating membrane formation was carried out at least, non-magnetic layer film of the above 2nd, ferromagnetic layer membrane of the above 2nd, and aforementioned antiferromagnetism layer membrane are deleted. By forming the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd f rromagnetic, and antiferromagnetism film of a right-and-left couple on the aforementioned free magnetic layer, respectively The manufacture method of the thin film magnetic head according to claim 16 characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple.
[Claim 19] After forming the 1st nonmagnetic membrane so that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered in the 2nd process of a claim 16, Laminating membrane formation formation of the 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one on it, respectively. The manufacture method of the thin film magnetic head according to claim 16 characterized by having the 2nd process which forms the vertical bias layer of a right-and-left couple which consists of the 1st nonmagnetic membrane of th above, the 1st ferromagnetic of the above of a right-and-left couple, the 2nd nonmagnetic membrane of the above, the 2nd ferromagnetic of the above, and an antiferromagnetism film of a right-and-left couple.
[Claim 20] An electrode lead layer membrane is formed so that the upper surface which the aforementioned antiferromagnetism film of the right-and-left couple formed in the topmost part of the aforementioned laminating length bias layer and the aforementioned nonmagnetic membrane, or the aforementioned magnetoresistance-effect element exposed may be worn. So that a part of aforementioned nonmagnetic membrane or a part of aforementioned magnetoresistance-effect element may be exposed The manufacture method of the claim 12 characterized by deleting a part of aforementioned electrode lead layer membrane, and having the 3rd process which forms the electrode lead layer of a right-and-left couple - a claim 14, or the thin film magnetic head according to claim 16 to 18.
[Claim 21] After forming an electrode lead layer membrane so that the upper surface which the aforementioned nonmagnetic membrane formed by the aforementioned antiferromagnetism film and the bottom of a right-and-left couple which were formed in the topmost part of the aforementioned laminating length bias layer exposed may be worn, The manufacture method of the thin film magnetic head according to claim 15 characterized by deleting a part of aforementioned electrode lead layer membrane, and having the 3rd process which forms the electrode lead layer of a right-and-left couple so that a part of aforementioned nonmagnetic membrane or aforementioned magnetoresistance-effect element may be exposed.
[Claim 22] After forming an electrode lead layer membrane so that the upper surface which the 1st nonmagnetic

membrane of the above formed by the aforementioned antiferromagnetism film and the bottom of a right-and-left couple which were formed in the topmost part of the aforementioned laminating length bias layer exposed may be worn, The manufacture method of the thin film magnetic head according to claim 19 characterized by deleting a part of aforementioned electrode lead layer membrane, and having the 3rd process which forms the electrode lead layer of a right-and-left couple so that a part of 1st nonmagnetic membrane of the above or aforementioned magnetoresistance-effect element may be exposed.

[Claim 23] On [some] the upper surface which the aforementioned antiferromagnetism film of the right-and-left couple which formed the resist and was formed in the topmost part of the aforementioned laminating length bias layer in the 3rd process of a claim 12 and the aforementioned nonmagnetic membrane, or the aforementioned magnetoresistance-effect element exposed The manufacture method of the claim 12 characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple - a claim 14, or the thin film magnetic head according to claim 16 to 18.

[Claim 24] The manufacture method of the thin film magnetic head according to claim 15 characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple on [some] the upper surface which the aforementioned nonmagnetic membrane formed by the aforementioned antiferromagnetism film and the bottom of a right-and-left couple which formed the resist and were formed in the topmost part of the aforementioned laminating length bias layer exposed.

[Claim 25] The manufacture method of the thin film magnetic head according to claim 19 characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple on [some] the upper surface which the 1st nonmagnetic membrane of the above formed by the aforementioned antiferromagnetism film and the bottom of a right-and-left couple which formed the resist and were formed in the topmost part of the aforementioned laminating length bias layer exposed.

[Claim 26] The 2nd process of a claim 12 and the 3rd process which are characterized by providing the following. The 2nd process which carries out laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one so that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered. Furthermore, so that a part of aforementioned free magnetic layer formed in some aforementioned non-magnetic layer films or the topmost part of the aforementioned magnetoresistance-effect element may be exposed, after forming an electrode lead layer membrane so that the aforementioned antiferromagnetism layer membrane may be covered on it A part of aforementioned ferromagnetic layer membrane by which laminating membrane formation was carried out at least, aforementioned antiferromagnetism layer membrane, and aforementioned electrode lead layer membrane are deleted. The 3rd process which forms the nonmagnetic membrane, the ferromagnetic, antiferromagnetism film, and electrode lead layer of a right-and-left couple on the aforementioned free magnetic layer, respectively, and forms the laminating length bias layer of a right-and-left couple which consists of the aforementioned nonmagnetic membrane, the aforementioned ferromagnetic, and the aforementioned antiferromagnetism film of a right-and-left couple, respectively, and the aforementioned electrode lead layer of a right-and-left couple.

[Claim 27] The 2nd process of a claim 16 and the 3rd process which are characterized by providing the following. Th 2nd process which carries out laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one so that the aforementioned free magnetic layer top formed in the topmost part of the aforementioned magnetoresistance-effect element may be covered. Furthermore, so that a part of aforementioned free magnetic layer formed in some non-magnetic layer films of the above 1st or the topmost part of the aforementioned magnetoresistance-effect element may be exposed, after forming an electrode lead layer membrane so that the aforementioned antiferromagnetism layer membrane may be covered on it A part of the ferromagnetic layer membrane of the above 1st by which laminating membrane formation was carried out at least, the non-magnetic layer film of th above 2nd, ferromagnetic layer membrane of the above 2nd, aforementioned antiferromagnetism layer membrane, and aforementioned electrode lead layer membrane are deleted. On the aforementioned free magnetic layer, respectively The 1st nonmagnetic membrane of a right-and-left couple, the 1st ferromagnetic, The 2nd nonmagnetic membrane, 2nd ferromagnetic, antiferromagnetism film, and electrode lead layer are formed. The 3rd process which forms the laminating length bias layer of a right-and-left couple which consists of the 1st nonmagnetic membrane of the above, the 1st ferromagnetic of the above, the 2nd nonmagnetic membrane of the above, the 2nd ferromagnetic of the above, and the aforementioned antiferromagnetism film of a right-and-left couple, respectively, and the aforementioned electrode lead layer of a right-and-left couple.

[Claim 28] The manufacture method of the thin film magnetic head according to claim 12 to 27 characterized by having the 4th process which forms the cap layer of the sake on antioxidizing and an anti-corrosion disposition on the upper surface which the aforementioned free magnetic layer at the topmost part of the aforementioned electrode lead layer of a right-and-left couple and the aforementioned magnetoresistance-effect element or the aforementioned non-magnetic layer film exposed.

[Claim 29] An antiferromagnetism layer is formed on the upper surface of the lower gap insulating layer formed on th lower shield layer. Furthermore, on it, form the laminating fixed magnetic layer which consists of the 1st fixed magnetic layer film, a non-magnetic layer film, and the 2nd fixed magnetic layer film, and laminating membrane formation of a nonmagnetic conductive layer and the free magnetic layer is carried out one by one at a it top. The manufacture method of the thin film magnetic head according to claim 12 to 28 characterized by having the 1st process which forms a magnetoresistance-effect element.

[Claim 30] On the lower gap insulating layer formed on the lower shield layer, an antiferromagnetism layer, Laminating membrane formation of a fixed magnetic layer and the nonmagnetic conductive layer is carried out one by one, and soft magnetic materials of a different kind are further used on it. The 1st free magnetic layer film, The 2nd free magnetic layer film, ..., the laminating free magnetic layer that carried out laminating membrane formation of the n-th free magnetic layer film (n is two or more positive integers) are formed. The manufacture method of the thin film magnetic head according to claim 12 to 29 characterized by having the 1st process which forms a magnetoresistance-effect element.

[Claim 31] The manufacture method of the thin film magnetic head characterized by providing the following. The 1st process which carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer one by one, forms a magnetoresistance-effect element in the upper surface of the lower gap insulating layer formed on the lower shield layer, and forms a cap layer on it further.

Form a resist, delete a part of aforementioned cap layer on the aforementioned magnetoresistance-effect element, and the aforementioned free magnetic layer is exposed. On the exposed aforementioned free magnetic layer, laminating membrane formation of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. The 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of the aforementioned nonmagnetic membrane, the aforementioned ferromagnetic, and the aforementioned antiferromagnetism film, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the aforementioned antiferromagnetism film formed in the topmost part of the aforementioned laminating length bias layer.

[Claim 32] Delete a part of aforementioned cap layer which formed the resist and was formed on the aforementioned magnetoresistance-effect element in the 2nd process of a claim 31, and the aforementioned free magnetic layer is exposed. On the exposed aforementioned free magnetic layer, laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. The manufacture method of the thin film magnetic head according to claim 31 characterized by having the 3rd process which forms the laminating length bias layer of a right-and-left couple.

[Claim 33] In the 1st process of a claim 31, on the upper surface of the lower gap insulating layer formed on the lower shield layer Form an antiferromagnetism layer, form further the laminating fixed magnetic layer which consists of the 1st fixed magnetic layer film, a non-magnetic layer film, and the 2nd fixed magnetic layer film on it, and laminating membrane formation of a nonmagnetic conductive layer and the free magnetic layer is carried out one by one on it. The manufacture method of the thin film magnetic head given in either the claim 31 which forms a magnetoresistance-effect element and is further characterized by having the 1st process which forms a cap layer on it, or the claim 32.

[Claim 34] In the 1st process of a claim 31, on the upper surface of the lower gap insulating layer formed on the lower shield layer Laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, and the nonmagnetic conductive layer is carried out one by one. further on it The 1st free magnetic layer film, the 2nd free magnetic layer film, ..., the laminating free magnetic layer that carried out laminating membrane formation of the n-th free magnetic layer film (n is two or more positive integers) are formed using soft magnetic materials of a different kind. The manufacture method of the thin film magnetic head according to claim 31 to 33 which forms a magnetoresistance-effect element and is further characterized by having the 1st process which forms a cap layer on it.

[Claim 35] An electrode lead layer membrane is formed so that the upper surface which the aforementioned antiferromagnetism film of the right-and-left couple formed in the topmost part of the aforementioned laminating length bias layer and the aforementioned cap layer exposed in the 3rd process of a claim 31 may be worn. The manufacture method of the thin film magnetic head according to claim 31 to 34 characterized by deleting a part of aforementioned electrode lead layer membrane, and having the 3rd process which forms the electrode lead layer of a right-and-left couple so that a part of aforementioned cap layer or magnetoresistance-effect element may be exposed.

[Claim 36] The manufacture method of the thin film magnetic head according to claim 31 to 34 characterized by having the 3rd process which forms a resist and forms the electrode lead layer of a right-and-left couple on [some] the upper surface which the aforementioned antiferromagnetism film of the right-and-left couple formed in the topmost part of the aforementioned laminating length bias layer and the aforementioned cap layer exposed in the 3rd process of a claim 31.

[Claim 37] So that the upper surface of the free magnetic layer at the topmost part of the aforementioned magnetoresistance-effect element may be worn So that some aforementioned non-magnetic layer films or a part of aforementioned free magnetic layer may be exposed after laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane is carried out one by one and A part of aforementioned non-magnetic layer film by which the laminating was carried out, aforementioned ferromagnetic layer membrane, and aforementioned antiferromagnetism layer membrane are deleted. Before forming the laminating length bias layer of a right-and-left couple, the direction of each magnetization of the aforementioned fixed magnetic layer which constitutes the aforementioned ferromagnetic layer membrane and the aforementioned magnetoresistance-effect element by which laminating membrane formation was carried out The manufacture method of the thin film magnetic head according to claim 14 characterized by adding heat treatment to the aforementioned antiferromagnetism layer of the aforementioned antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and the aforementioned magnetoresistance-effect element.

[Claim 38] So that the upper surface of the aforementioned free magnetic layer at the topmost part of the aforementioned magnetoresistance-effect element may be worn So that some non-magnetic layer films of the above 1st or a part of aforementioned free magnetic layer may be exposed after laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane is carried out one by one and A part of the ferromagnetic layer membrane of the above 1st by which the laminating was carried out at least, non-magnetic layer film of the above 2nd, ferromagnetic layer membrane of the above 2nd, and aforementioned antiferromagnetism layer membrane are deleted. The ferromagnetic layer membrane of the above 1st by which laminating membrane formation was carried out before forming the laminating length bias layer of a right-and-left couple, The direction of each magnetization of the aforementioned fixed magnetic layer which constitutes the ferromagnetic layer membrane and the aforementioned magnetoresistance-effect element of the above 2nd The manufacture method of the thin film magnetic head according to claim 18 characterized by adding heat treatment to the antiferromagnetism layer of the aforementioned antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and the aforementioned magnetoresistance-effect element.

[Claim 39] So that the upper surface of the aforementioned free magnetic layer at the topmost part of the aforementioned magnetoresistance-effect element may be worn So that some aforementioned non-magnetic layer films or a part of aforementioned free magnetic layer may be exposed after laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, an antiferromagnetism layer membrane, and the electrode lead layer membrane is carried out one by one and A part of aforementioned ferromagnetic layer membrane by which the laminating was carried out at least, aforementioned antiferromagnetism layer membrane, and aforementioned electrode lead layer membrane are deleted. Before forming the laminating length bias layer and electrode lead layer of a

right-and-left couple, respectively The direction of each magnetization of the aforementioned fixed magnetic layer which constitutes the aforementioned ferromagnetic layer membrane and the aforementioned magnetoresistance-effect element by which laminating membrane formation was carried out The manufacture method of the thin film magnetic head according to claim 26 characterized by adding heat treatment to the aforementioned antiferromagnetism layer of the aforementioned antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and the aforementioned magnetoresistance-effect element.

[Claim 40] So that the upper surface of the aforementioned free magnetic layer at the topmost part of the aforementioned magnetoresistance-effect element may be worn The 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, So that some non-magnetic layer films of the above 1st or a part of aforementioned free magnetic layer may be exposed after laminating membrane formation of an antiferromagnetism layer membrane and the electrode lead layer membrane is carried out one by one and A part of the ferromagnetic layer membrane of the above 1st by which the laminating was carried out at least, the non-magnetic layer film of the above 2nd, ferromagnetic layer membrane of the above 2nd, aforementioned antiferromagnetism layer membrane, and aforementioned electrode lead layer membrane are deleted. Before forming the laminating length bias layer and electrode lead layer of a right-and-left couple, respectively The direction of each magnetization of the aforementioned fixed magnetic layer which constitutes the ferromagnetic layer membrane of the above 1st by which laminating membrane formation was carried out, the ferromagnetic layer membrane of the above 2nd, and the aforementioned magnetoresistance-effect element The manufacture method of the thin film magnetic head according to claim 27 characterized by adding heat treatment to the aforementioned antiferromagnetism layer of the aforementioned antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and the aforementioned magnetoresistance-effect element.

[Claim 41] On the upper surface which the aforementioned free magnetic layer at the topmost part of the aforementioned electrode lead layer of a right-and-left couple and the aforementioned magnetoresistance-effect element or the aforementioned non-magnetic layer film exposed The aforementioned cap layer, the aforementioned electrode lead layer of a right-and-left couple which were formed after the cap layer was formed, Patterning of the laminating length bias layer and the aforementioned magnetoresistance-effect element of a right-and-left couple is carried out to a predetermined configuration, and they are shaved off. Before an up gap insulating layer is formed, the direction of each magnetization of the aforementioned fixed magnetic layer which constitutes the aforementioned ferromagnetic and the aforementioned magnetoresistance-effect element which constitute the aforementioned laminating length bias layer The manufacture method of the thin film magnetic head according to claim 28 characterized by adding heat treatment to the aforementioned antiferromagnetism layer of the aforementioned antiferromagnetism layer membrane which constitutes the aforementioned laminating length bias layer so that it may become in each predetermined direction, and the aforementioned magnetoresistance-effect element.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention is applied to the equipment which performs high-density record and reproduction to magnetic-recording media, such as a magnetic disk unit (HDD equipment), gives the bias magnetic field especially stabilized in the free magnetic layer of a magnetoresistance-effect element, and relates to the high magnetoresistance-effect type thin film magnetic head and its manufacture method of a regeneration efficiency.
[0002]
[Description of the Prior Art] In recent years, in the record and reproduction to magnetic-recording media, such as a magnetic disk unit (HDD equipment), improvement in processing speed and the need for large-capacity-izing of storage capacity are increasing, and the measure for a raise in recording density is being strengthened.
[0003] Hereafter, the conventional thin film magnetic head is explained using a drawing.
[0004] Drawing 23 and drawing 24 are drawings showing the conventional thin film magnetic head, drawing 23 is a tropia schematic diagram and drawing 24 is the transverse-plane ****** type view of the thin film magnetic head.
[0005] For example, the thin film magnetic head used for the record reproduction to the magnetic-recording medium of the signal in a magnetic disk unit has many which are called so-called MR (GMR) inductive combined head as shown in drawing 23 .
[0006] In drawing 23 , the nonmagnetic insulating material of aluminum2O3, AlN, or SiO2 grade is used on the lower shield layer 231 formed by soft magnetic materials, such as a permalloy, Co system amorphous magnetic film, or Fe system alloy magnetic film, the lower gap insulating layer 232 is formed, and it is a magnetoresistance-effect element (MR element or GMR element.) to the upper surface further. Laminating membrane formation formation of the 233 called GMR element is carried out hereafter, and the vertical bias layer 234 is formed by the right-and-left both-sides edge of the GMR element 233 with material, such as a CoPt alloy. The ridgeline which is a nodal line of the upper surface and the both-sides side of the GMR element 233 to make is touched, and the electrode lead layer 235 is formed using material, such as Cu, Cr, or Ta, so that membranes may be formed on the upper surface of the vertical bias layer 234. Here, as the electrode lead layer 235 starts the upper surface of the vertical bias layer 234, and the upp r surface of a part of GMR element 233, it may form the electrode lead layer 235. Next, the up gap insulating layer 236 is formed on the portion which the electrode lead layer 235 and the GMR element 233 exposed using the same nonmagnetic insulating material as the lower gap insulating layer 232. Furthermore, on the up gap insulating layer 236, membrane formation formation of the up shield layer 237 is carried out using the same soft magnetic materials as the lower shield layer 231, and the magnetoresistance-effect type thin film magnetic-head section 238 for reproduction is constituted.
[0007] Next, the record gap layer 241 is formed using the same nonmagnetic insulating material as the lower gap insulating layer 232 on the upper surface of the up shield layer 237. Furthermore, the up shield layer 237 is countered through the record gap layer 241. And membrane formation formation of the up magnetic pole 242 which is in contact with the up shield layer 237 is carried out using soft magnetic materials in other portions. Between the up shield layer 237, the portion which the up magnetic pole 242 has countered, and the portion to which the up magnetic pole 242 is in contact with the up shield layer 237, through the record gap layer 241 The coil coil 243 insulated from the up shield layer 237 and the up magnetic pole 242 through the insulating material (not shown) is formed, and the induction-type thin film magnetic-head section 240 for record is constituted. Here, the up shield layer 237 has the function which combines the shield function of the magnetoresistance-effect type thin film magnetic-head section 238 for repr duction, and the lower magnetic pole function of the induction-type thin film magnetic-head section 240 for record.
[0008] As the transverse-plane ****** type view near [in the reproducing-head section of the thin film magnetic head] the magnetoresistance-effect element is shown in drawing 24 On the lower gap insulating layer 232 formed by the upper surface of the lower shield layer 231 The antiferromagnetism layer 244, NiFe system alloy film which are material, such as a FeMn system alloy film and a PtMn system alloy film Laminating membrane formation of the cap layer 248 mad from the nonmagnetic conductive layer 246 made from the fixed magnetic layer 245 made from Co, a CoFe alloy film, etc., Cu, etc., the fixed magnetic layer 245 and the free magnetic layer 247 made into the same material, Ta, etc. is carried out one by one. It is shaved off so that it may have the field where the right-and-left both-sides edge inclined at etching processes, such as ion milling, and the GMR element 233 is formed. The right-and-left both-sides end face of the GMR element 233 is touched, the vertical bias layer 234 of a right-and-left couple is formed, and the electrode lead layer 235 of a right-and-left couple is formed on it. Furthermore, on them, the up gap insulating layer 236 is formed and the up shield layer 237 is further formed on it. In order to reproduce the record signal of the short wavelength corresponding to a raise in recording density in recent years, the reproduction head gap length 249 is becoming still smaller.
[0009] By supplying record current to the coil coil 243, a record magnetic field occurs in th up magnetic pole 242 and the up shield layer 237 of the induction-type thin film magnetic-head section 240 for record, magnetic leakage flux occurs between the up magnetic poles 242 and the up shield layers 237 which counter through the record gap layer 241, and a record signal is recorded on a magnetic-recording medium. Moreover, the signal magnetic field from the magnetic-recording medium by which the signal was recorded is reproduced in the magnetoresistance-effect type thin film magnetic-head section 238 for reproduction, and the regenerative signal according to the resistance change by the GMR element 233 is detected from the terminal of the electrode lead layer 235.
[0010]

[Problem(s) to be Solved by the Invention] However, in the reproducing-head section of the thin film magnetic head of the above-mentioned conventional composition, in order to reproduce the signal recorded on the magnetic-recording medium by short wavelength, it is necessary to make reproduction head gap length small. Reproduction head gap length The distance, i.e., the lower gap insulating layer, from the upper surface of a lower shield layer to the inferior surface of tongue of an up shield layer, Are the sum of each thickness of a GMR element and an up gap insulating layer, and the vertical bias layer of the right-and-left couple which making this distance small has in the both sides of a GMR element will approach a lower shield layer or an up shield layer. The bias magnetic field which the magnetic field of a vertical bias layer becomes easy to escape in a lower shield layer or an up shield layer, and requires it for the free magnetic layer of a GMR element became weaker, the direction of magnetization of a free magnetic layer became unstable, the noise increased and the technical problem that the stable regenerative signal was not obtained occurred.
[0011] this invention solves the above-mentioned technical problem, makes what was accurate and was stabilized the bias magnetic field which starts the free magnetic layer of a GMR element from a vertical bias layer, stabilizes the direction of magnetization of a free magnetic layer, suppresses generating of a Barkhausen noise, and aims at offering the good magnetoresistance-effect type thin film magnetic head and its manufacture method of reproducibility ability.
[0012]
[Means for Solving the Problem] In order to attain this purpose, the thin film magnetic head of this invention has the composition it was made to consist of a magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, and a laminating length bias layer of a right-and-left couple which consists of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple on the free magnetic layer which constitutes a magnetoresistance-effect element, respectively. Moreover, the thin film magnetic head of this invention has composition which has the thickness of the nonmagnetic membrane of the right-and-left couple which constitutes a laminating length bias layer from which the direction of magnetization of the free magnetic layer which constitutes the magnetoresistance-effect element of the portion which has countered the ferromagnetic of a right-and-left couple through the nonmagnetic membrane of a right-and-left couple turns into the direction and opposite direction of magnetization of a ferromagnetic of a right-and-left couple.
[0013] By constituting the free magnetic layer which counters a ferromagnetic by this composition through the nonmagnetic membrane which has suitable thickness As compared with the case where the laminating of the direct antiferromagnetism material is carried out to a free magnetic layer, the direction of magnetization of a free magnetic layer (for example, the direction of X) is fixed more strongly. by one side The portion of the free magnetic layer between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple is also stabilized, and it becomes easy to turn to it in the direction of X, and there is little generating of a Barkhausen noise and it can obtain the reproducibility ability stabilized in high sensitivity.
[0014] Moreover, the thin film magnetic head of this invention has the composition it was made to consist of a magnetoresistance-effect element which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, and a laminating length bias layer of a right-and-left couple which consists of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple on the free magnetic layer which constitutes a magnetoresistance-effect element, respectively. Moreover, the thin film magnetic head of this invention has the thickness of the 1st nonmagnetic membrane of a right-and-left couple from which the direction of magnetization of a free magnetic layer turns into the 1st direction and opposite direction of magnetization of a ferromagnetic of a right-and-left couple. It has composition which has the thickness of the 2nd nonmagnetic membrane of a right-and-left couple from which the direction of magnetization of the 2nd ferromagnetic of a right-and-left couple turns into the 1st magnetization direction and opposite direction of a ferromagnetic layer of a right-and-left couple.
[0015] The free magnetic layer which counters the 1st ferromagnetic of a right-and-left couple by this composition through the 1st nonmagnetic membrane of the right-and-left couple which has suitable thickness As compared with the case where the laminating of the direct antiferromagnetism material is carried out, a switched connection magnetic field with the 1st ferromagnetic is very strong to a free magnetic layer. The direction of magnetization of the free magnetic layer of the portion which counters the 1st ferromagnetic of a right-and-left couple becomes what was stabilized very much. The direction of magnetization of the free magnetic layer between the portions which have countered the 1st ferromagnetic of a right-and-left couple also turns into the same direction. Furthermore, by making it counter with the 1st ferromagnetic and the 2nd ferromagnetic through the 2nd nonmagnetic membrane of thickness suitable as a laminating length bias layer The leakage magnetic field by end-face magnetic charge will be mutual-boiled, and will be negated mutually. It prevents the direction of the magnetization by the anti-magnetic field in the end face of a ferromagnetic inclining in the direction of Y, and it will gather to an edge, and to an external magnetic field, magnetization of a ferromagnetic also becomes the stable high sensitivity thing, and can obtain the outstanding reproducibility ability.
[0016] Moreover, the manufacture method of the thin film magnetic head of this invention Laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer is carried out one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. On the 1st process which forms a magnetoresistance-effect element, and the free magnetic layer at the topmost part of a magnetoresistance-effect element Carry out membrane formation formation of the nonmagnetic membrane of a right-and-left couple, carry out laminating membrane formation of the ferromagnetic of a right-and-left couple on it, and laminating membrane formation of the antiferromagnetism film of a right-and-left couple is further carried out on it. It has the 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic, and an antiferromagnetism film, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the antiferromagnetism film formed in the topmost part of a laminating length bias layer. Moreover, the manufacture method of the thin film magnetic head of this invention has the 2nd process which carries out laminating membrane formation of the nonmagnetic membrane of a right-and-left couple, the ferromagnetic of a right-and-left couple, and the antiferromagnetism film of a right-and-left couple, and forms the laminating length bias layer of a right-and-left couple on a free magnetic layer, after cleaning the free magnetic layer formed in the topmost part of a magnetoresistance-effect element. Moreover, the manufacture method of the thin film magnetic head of this invention Laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer is carried out one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. The 1st process which forms a magnetoresistance-effect

element and forms a cap layer on it further, Laminating membrane formation of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively on the free magnetic layer which formed the resist, deleted a part of cap layer on a magnetoresistance-effect element, was made to expose a free magnetic layer, and was exposed. It has the 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic, and an antiferromagnetism film, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the antiferromagnetism film formed in the topmost part of a laminating length bias layer.

[0017] The free magnetic layer which considered as the composition used as the laminating length bias layer as a vertical bias layer which gives the direction of magnetization to a free magnetic layer, and countered the ferromagnetic through the nonmagnetic membrane of a right-and-left couple by this method In the portion which has countered, as compared with the case where the free magnetic layer is in contact with the direct antiferromagnetism film, a switch d connection magnetic field with a very strong ferromagnetic is acquired, it is stabilized and the direction of magnetization of a free magnetic layer is held. by one side The portion of the free magnetic layer between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple It becomes easy to be suitable in the same direction as the portion of the free magnetic layer of the right and left which were stabilized and have countered the ferromagnetic of a right-and-left couple, and there is little generating of a Barkhausen noise and it can produce the magnetoresistance-effect type thin film magnetic head for reproduction which has the stable high sensitivity reproducibility ability.

[0018] Moreover, the manufacture method of the thin film magnetic head of this invention Laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer is carried out one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. On the 1st process which forms a magnetoresistance-effect element, and the free magnetic layer formed in the topmost part of a magnetoresistance-effect element Laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. It has the 2nd process which forms the laminating length bias layer of a right-and-left couple, and the 3rd process which forms the electrode lead layer of a right-and-left couple on the antiferromagnetism film formed in the topmost part of a laminating length bias layer.

[0019] The free magnetic layer which considered as the composition used as the laminating length bias layer as a vertical bias layer which gives the direction of magnetization to a free magnetic layer, and countered the ferromagnetic through the nonmagnetic membrane of a right-and-left couple by this method In the portion which has countered, as compared with the case where the free magnetic layer is in contact with the direct antiferromagnetism film, a switched connection magnetic field with a very strong ferromagnetic is acquired, it is stabilized and the direction of magnetization of a free magnetic layer is held. by one side The portion of the free magnetic layer between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple Become easy to be suitable in the same direction as the portion of the free magnetic layer of the right and left which were stabilized and have countered the ferromagnetic of a right-and-left couple. Furthermore, the leakage magnetic field by the end-face magnetic charge of the ferromagnetic of a laminating length bias layer will be mutually negated by the 1st ferromagnetic and 2nd ferromagnetic. And it prevents the direction of the magnetization by the anti-magnetic field in the end face of a ferromagnetic inclining in the direction of Y. Magnetization of a ferromagnetic will also gather to an edge, becomes that by which the direction of magnetization of a free magnetic layer was stabilized more, and can produce the magnetoresistance-effect type thin film magnetic head for reproduction which has the reproducibility ability stabilized further.

[0020]

[Embodiments of the Invention] The vertical bias layer which invention of this invention according to claim 1 has a magnetoresistance-effect element through an insulating material between a lower shield layer and an up shield layer, and was prepared in contact with the magnetoresistance-effect element, In the magnetoresistance-effect type thin film magnetic head which consists of an electrode lead layer for passing the signal current The magnetoresistance-effect el ment which consists of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, On the free magnetic layer which constitutes a magnetoresistance-effect element, respectively Th nonmagnetic membrane of a right-and-left couple, It is characterized by consisting of laminating length bias layers of a right-and-left couple which consist of a ferromagnetic and an antiferromagnetism film. moreover, invention of this invention according to claim 2 The direction of magnetization of the free magnetic layer which constitutes the magnetoresistance-effect element of the portion which has countered the ferromagnetic of a right-and-left couple through th nonmagnetic membrane of a right-and-left couple It is characterized by having the thickness of the nonmagnetic membrane of the right-and-left couple which constitutes a laminating length bias layer which becomes the direction and opposite direction of magnetization of a ferromagnetic of a right-and-left couple. It is characterized by the range whose thickness of the nonmagnetic membrane of a right-and-left couple is 0.4-3nm having invention of this invention according to claim 3. moreover, moreover, invention of this invention according to claim 7 It is characterized by having the cap layer which is between the laminating length bias layers of a right-and-left couple, and touched the upper surface of a magnetoresistance-effect element. moreover, invention of this invention according to claim 8 It is characterized by consisting of laminating fixed magnetic layers to which the fixed magnetic layer which constitutes a magnetoresistance-effect element carried out the laminating of the two fixed magnetic layer films which counter through a non-magnetic layer film. Moreover, invention of this invention according to claim 9 is set to a laminating fixed magnetic layer. It is characterized by having the thickness of a non-magnetic layer film which becomes each other in the reverse direction about the direction of magnetization of the fixed magnetic layer film which countered through the non-magnetic layer film. Moreover, the free magnetic layer which constitutes a magnetoresistance-effect element invention of this invention according to claim 11 It is characterized by constituting the material of the adjacent free magnetic layer film from a laminating free magnetic layer by which two or more layer laminating was carried out by soft magnetic materials of a different kind. as a vertical bias layer The laminating of a ferromagnetic and the antiferromagnetism film is carried out. by the switched connection magnetic field with an antiferromagnetism film By constituting the free magnetic layer which counters a ferromagnetic through the nonmagnetic membrane which the direction of magnetization of a ferromagnetic is arranged in the fixed direction (for example, the direction of -X), and has suitable thickness As compared with the case where the laminating of the direct antiferromagnetism material is carried out to a free magnetic layer, the direction of magnetization of a free magnetic layer (for example, the direction of X) is fixed more strongly. by one side The portion of the free magnetic layer which constitutes the GMR element

between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple It is stabilized, becomes easy to be suitable in the direction of X, and will become very stable, and there is little generating of a Barkhausen noise and it has the operation that the reproducibility ability stabilized in high sensitivity can be obtained.

[0021] Moreover, the magnetoresistance-effect element which invention of this invention according to claim 4 becomes from an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and a free magnetic layer, On the free magnetic layer which constitutes a magnetoresistance-effect element, respectively The 1st nonmagnetic membrane of a right-and-left couple, It is characterized by consisting of laminating length bias layers of a right-and-left couple which consist of the 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film. Invention of this invention according to claim 5 moreover, the direction of magnetization of a free magnetic layer It has the thickness of the 1st nonmagnetic membrane of a right-and-left couple which becomes the 1st direction and opposite direction of magnetization of a ferromagnetic of a right-and-left couple. It is characterized by having the thickness of the 2nd nonmagnetic membrane of a right-and-left couple from which the direction of magnetization of the 2nd ferromagnetic of a right-and-left couple turns into the 1st magnetization direction and opposite direction of a ferromagnetic layer of a right-and-left couple. Invention of this invention according to claim 6 moreover, the thickness of the 1st nonmagnetic membrane of a right-and-left couple It is characterized by being in the range of 0.4-3nm, and being in the range whose thickness of the 2nd nonmagnetic membrane of a right-and-left couple is 0.4-3nm. by the switched connection magnetic field between the 2nd ferromagnetic and an antiferromagnetism film The direction of magnetization of the 1st ferromagnetic which counters the 2nd ferromagnetic of a right-and-left couple through the 2nd nonmagnetic membrane of the right-and-left couple which the direction of magnetization of the 2nd ferromagnetic is arranged in the fixed direction, and has suitable thickness is arranged with the 2nd direction and opposite direction of magnetization of a ferromagnetic. again The free magnetic layer which counters the 1st ferromagnetic of a right-and-left couple through the 1st nonmagnetic membrane of the right-and-left couple which has suitable thickness A switched connection magnetic field with the 1st ferromagnetic is very strong, and it turns [direction / of magnetization of the free magnetic layer of the portion which counters the 1st ferromagnetic of a right-and-left couple] to the 1st direction and opposite direction of magnetization of a ferromagnetic. Become what was stabilized very much and the direction of magnetization of the free magnetic layer between the portions which have countered the 1st ferromagnetic of a right-and-left couple also turns into the same direction. Furthermore, by making it counter with the 1st ferromagnetic and the 2nd ferromagnetic through the 2nd nonmagnetic membrane as a laminating length bias layer The leakage magnetic field by end-face magnetic charge will be mutual-boiled, and will be negated mutually. It prevents the direction of the magnetization by the anti-magnetic field in the end face of a ferromagnetic inclining in the direction of Y, and it will gather to an edge, and to an external magnetic field, magnetization of a ferromagnetic also becomes the stable high sensitivity thing, and can obtain the outstanding reproducibility ability.

[0022] Moreover, invention of this invention according to claim 12 carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. On the 1st process which forms a magnetoresistance-effect element, and the free magnetic layer at the topmost part of a magnetoresistance-effect element Carry out membrane formation formation of the nonmagnetic membrane of a right-and-left couple, carry out laminating membrane formation of the ferromagnetic of a right-and-left couple on it, and laminating membrane formation of the antiferromagnetism film of a right-and-left couple is further carried out on it. The 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic, and an antiferromagnetism film, It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple on the antiferromagnetism film formed in the topmost part of a laminating length bias layer. Moreover, invention of this invention according to claim 13 is set at the 2nd process of a claim 12. After cleaning the free magnetic layer formed in the topmost part of a magnetoresistance-effect el ment, laminating membrane formation of the nonmagnetic membrane of a right-and-left couple, the ferromagnetic of a right-and-left couple, and the antiferromagnetism film of a right-and-left couple is carried out on a free magnetic layer. It is characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple. moreover, invention of this invention according to claim 14 So that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 12 So that a part of fr e magnetic layer formed in a part of nonmagnetic membrane or the topmost part of a magnetoresistance-effect l ment may be exposed, after carrying out laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one By deleting a part of ferromagnetic layer membrane by which laminating membrane formation was carried out at least, and antiferromagnetism layer membrane, and forming the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple on a free magnetic layer, respectively It is characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple. moreover, invention of this invention according to claim 15 After forming a nonmagnetic membrane so that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 12, laminating membrane formation formation of the ferromagnetic and antiferromagnetism film of a right-and-left couple is carried out one by one on it, respectively. It is characterized by having the 2nd process which forms the vertical bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic of a right-and-left couple, and an antiferromagnetism film of a right-and-left couple. Moreover, invention of this invention according to claim 20 forms an electrode lead layer membrane so that the upper surface which the antiferromagnetism film of the right-and-left couple formed in the topmost part of a laminating length bias layer and the magnetoresistance-effect element exposed may be worn. A part of el ctrode lead layer membrane is deleted so that a part of magnetoresistance-effect element may be exposed. It is characterized by having the 3rd process which forms the electrod lead layer of a right-and-left couple. moreover, invention of this invention according to claim 21 After forming an electrode lead layer membrane so that the upper surface which the nonmagnetic membrane formed by the antiferromagnetism film and the bottom of a right-and-left couple which were formed in the topmost part of a laminating length bias layer exposed may be worn, so that a part of nonmagnetic membrane or magnetoresistance-effect element may be exposed A part of electrode lead layer membrane is deleted, and it is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 23 On [some] the upper surface which the antiferromagnetism film of the right-and-left couple which formed the resist and was formed in the topmost part of a

laminating length bias layer in the 3rd process of a claim 12, and the magnetoresistance-effect element exposed It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 24 On [some] the upper surface which the nonmagnetic membrane formed by the antiferromagnetism film and the bottom of a right-and-left couple which formed the resist and were formed in the topmost part of a laminating length bias layer exposed It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 26 The 2nd process which carries out laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one so that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 12, and the 3rd process, Furthermore, so that a part of free magnetic layer formed in some non-magnetic layer films or the topmost part of a magnetoresistance-effect element may be exposed, after forming an electrode lead layer membrane so that an antiferromagnetism layer membrane may be covered on it A part of ferromagnetic layer membrane by which laminating membrane formation was carried out at least, antiferromagnetism layer membrane, and electrode lead layer membrane are deleted. The nonmagnetic membrane, the ferromagnetic, antiferromagnetism film, and electrode lead layer of a right-and-left couple are formed on the aforementioned free magnetic layer, respectively. It is characterized by having the 3rd process which forms the laminating length bias layer of a right-and-left couple which consists of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple, respectively, and the electrode lead layer of a right-and-left couple. Invention of this invention according to claim 28 on moreover, the upper surface which the free magnetic layer at the topmost part of the electrode lead layer of a right-and-left couple and a magnetoresistance-effect element or the non-magnetic layer film exposed It is characterized by having the 4th process which forms the cap layer of the sake on antioxidizing and an anti-corrosion disposition. moreover, invention of this invention according to claim 29 An antiferromagnetism layer is formed on the upper surface of the lower gap insulating layer formed on the lower shield layer. Furthermore, on it, form the laminating fixed magnetic layer which consists of the 1st fixed magnetic layer film, a non-magnetic layer film, and the 2nd fixed magnetic layer film, and laminating membrane formation of a nonmagnetic conductive layer and the free magnetic layer is carried out one by one at a it top. the lower gap insulating-layer [which is characterized by having the 1st process which forms a magnetoresistance-effect element] top by which invention of this invention according to claim 30 was formed on the lower shield layer -- an antiferromagnetism layer and a fixed magnetic layer -- and current is nonmagnetic-conducted Carry out laminating membrane formation of the layer one by one, and the 1st free magnetic layer film, the 2nd free magnetic layer film, ..., the laminating free magnetic layer that carried out laminating membrane formation of the n-th free magnetic layer film (n is two or more positive integers) are further formed on it using soft magnetic materials of a different kind. It is characterized by having the 1st process which forms a magnetoresistance-effect element. moreover, invention of this invention according to claim 31 Laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer is carried out one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. The 1st process which forms a magnetoresistance-effect element and forms a cap layer on it further, Laminating membrane formation of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively on the free magnetic layer which formed the resist, deleted a part of cap layer on a magnetoresistance-effect element, was made to expose a free magnetic layer, and was exposed. The 2nd process which forms the laminating length bias layer of a right-and-left couple which consists of a nonmagnetic membrane, a ferromagnetic, and an antiferromagnetism film, It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple on the antiferromagnetism film formed in the topmost part of a laminating length bias layer. Moreover, invention of this invention according to claim 35 is set at the 3rd process of a claim 31. So that an electrode lead layer membrane may be formed so that the upper surface which the antiferromagnetism film of the right-and-left couple formed in the topmost part of a laminating length bias layer and the cap layer exposed may be worn, and a part of cap layer may be exposed A part of electrode lead layer membrane is deleted, and it is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 36 A resist is formed on [some] the upper surface which the antiferromagnetism film of the right-and-left couple formed in the topmost part of a laminating length bias layer and the cap layer exposed in the 3rd process of a claim 31. It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple, and the laminating of a ferromagnetic and the antiferromagnetism film is carried out as a vertical bias layer. by the switched connection magnetic field with an antiferromagnetism film By constituting the free magnetic layer which counters a ferromagnetic through the nonmagnetic membrane which the direction of magnetization of a ferromagnetic is arranged in the fixed direction (for example, the direction of -X), and has suitable thickness As compared with the case where the laminating of the direct antiferromagnetism material is carried out to a free magnetic layer, the direction of magnetization of a free magnetic layer (for example, the directi n of X) is fixed more strongly. by one side The portion of the free magnetic layer which constitutes the GMR element between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple It is stabilized, becomes easy to be suitable in the direction of X, and will become very stable, and there is little generating of a Barkhausen noise and it has the operation that the thin film magnetic head aiming at realization of the reproducibility ability stabilized in high sensitivity is producible.

[0023] Moreover, invention of this invention according to claim 16 carries out laminating membrane formation of an antiferromagnetism layer, a fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer one by one on the upper surface of the lower gap insulating layer formed on the lower shield layer. On the 1st process which forms a magnetoresistance-effect element, and the free magnetic layer formed in the topmost part of a magnetoresistance-effect element Laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. On the antiferromagnetism film formed in the 2nd process which forms the laminating length bias layer of a right-and-left couple, and the topmost part of a laminating length bias layer It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 17 After cleaning the free magnetic layer formed in the topmost part of a magnetoresistance-effect element in the 2nd process of a claim 16, On a free magnetic layer, laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one, respectively. It is characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple. moreover, invention of this

invention according to claim 18 So that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 16 After carrying out laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one, So that a part of free magnetic layer formed in a part of 1st non-magnetic layer film or the topmost part of a magnetoresistance-effect element may be exposed A part of the 1st ferromagnetic layer membrane by which laminating membrane formation was carried out at least, 2nd non-magnetic layer film, 2nd ferromagnetic layer membrane, and antiferromagnetism layer membrane are deleted. By forming the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple on a free magnetic layer, respectively It is characterized by having the 2nd process which forms the laminating length bias layer of a right-and-left couple. moreover, invention of this invention according to claim 19 After forming the 1st nonmagnetic membrane so that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 16, Laminating membrane formation formation of the 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left couple is carried out one by one on it, respectively. It is characterized by having the 2nd process which forms the vertical bias layer of a right-and-left couple which consists of the 1st nonmagnetic membrane, the 1st ferromagnetic of a right-and-left couple, the 2nd nonmagnetic membrane, the 2nd ferromagnetic, and an antiferromagnetism film of a right-and-left couple. Moreover, after forming an electrode lead layer membrane so that invention of this invention according to claim 22 may wear the upper surface which the 1st nonmagnetic membrane formed by the antiferromagnetism film and the bottom of a right-and-left couple which were formed in the topmost part of a laminating length bias layer exposed, A part of aforementioned electrode lead layer membrane is deleted so that a part of 1st nonmagnetic membrane or magnetoresistance-effect element may be exposed. It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 25 On [some] the upper surface which the 1st nonmagnetic membrane formed by the antiferromagnetism film and the bottom of a right-and-left couple which formed the resist and were formed in the t pmost part of a laminating length bias layer exposed It is characterized by having the 3rd process which forms the electrode lead layer of a right-and-left couple. moreover, invention of this invention according to claim 27 So that the free magnetic layer top formed in the topmost part of a magnetoresistance-effect element may be covered in the 2nd process of a claim 16, and the 3rd process The 1st non-magnetic layer film, The 2nd process which carries out laminating membrane formation of the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane one by one, Furthermore, so that a part of free magnetic layer formed in a part of 1st non-magnetic layer film or the topmost part of a magnetoresistance-effect element may be exposed, after forming an electrode lead layer membrane so that an antiferromagnetism layer m mbrane may be covered on it A part of the 1st ferromagnetic layer membrane by which laminating membrane formation was carried out at least, the 2nd non-magnetic layer film, 2nd ferromagnetic layer membrane, antiferromagnetism layer membrane, and electrode lead layer membrane are deleted. On a free magnetic layer, respectively The 1st nonmagnetic membrane of a right-and-left couple, the 1st ferromagnetic, The 2nd nonmagnetic membrane, 2nd ferromagnetic, antiferromagnetism film, and electrode lead layer are formed. Respectively The 1st nonmagnetic membrane of a right-and-left couple, the 1st ferromagnetic, the 2nd nonmagnetic membrane, It is characterized by having the 3rd process which forms the laminating length bias layer of a right-and-left couple which consists of the 2nd ferromagnetic and antiferromagnetism film, and the electrode lead layer of a right-and-left couple. Moreover, invention of this invention according to claim 32 is set at the 2nd process of a claim 31. Delete a part of cap layer which formed the resist and was formed on the magnetoresistance-effect element, and a free magnetic layer is exposed. On the exposed free magnetic layer, laminating membrane formation of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film of a right-and-left coupl is carried out one by one, respectively. It is characterized by having the 3rd process which forms the laminating length bias layer of a right-and-left couple. by the switched connection magnetic field between the 2nd ferromagnetic and an antiferromagnetism film The direction of magnetization of the 1st ferromagnetic which counters the 2nd ferromagnetic of a right-and-left couple through the 2nd nonmagnetic membrane of the right-and-left couple which the direction of magnetization of the 2nd ferromagnetic is arranged in the fixed direction, and has suitable thickness is arranged with the 2nd direction and opposite direction of magnetization of a ferromagnetic. again The free magnetic layer which counters the 1st ferromagnetic of a right-and-left couple through the 1st nonmagnetic membrane of the right-and-left couple which has suitable thickness A switched connection magnetic field with the 1st ferromagnetic is very strong, and it turns [direction / of magnetization of the free magnetic layer of the portion which counters the 1st ferromagnetic of a right-and-left couple] to the 1st direction and opposite direction of magnetization of a ferromagnetic. Become what was stabilized very much and the direction of magnetization of the free magnetic layer between the portions which have countered the 1st ferromagnetic of a right-and-left couple also turns into the same dir ction. Furthermore, by making it counter with the 1st ferromagnetic and the 2nd ferromagnetic through the 2nd nonmagnetic membrane as a laminating length bias layer The leakage magnetic field by end-face magnetic charge will be mutual-boiled, and will be negated mutually. It prevents the direction of the magnetization by the anti-magnetic field in th end face of a ferromagnetic inclining in the direction of Y. Magnetization of a ferromagnetic will also gather to an edge. and has the operation that the thin film magnetic head which aimed at high sensitivity realization of the reproducibility ability which became the stable thing and was excellent is producible to an external magnetic field.

[0024] Moreover, invention of this invention according to claim 37 so that the upper surface of the free magnetic layer at the topmost part of a magnetoresistance-effect element may be worn After laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, and the antiferromagnetism layer membrane is carried out one by one, and so that some non-magnetic layer films or a part of free magnetic layer may be exposed A part of ferromagnetic layer membrane by which the laminating was carried out at least, and antiferromagnetism layer m mbrane are deleted. Before forming the laminating length bias layer of a right-and-left couple, the direction of each magnetization of the fixed magnetic layer which constitutes the ferromagnetic layer membrane and magnetoresistance-effect element by which laminating membrane formation was carried out It is characterized by adding heat treatment to the antiferromagnetism layer of the antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and a magnetoresistance-effect element. Moreover, invention of this invention according to claim 38 so that the upper surface of the free magnetic layer at the topmost part of a magnetoresistance-effect element may be worn After

laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, and the antiferromagnetism layer membrane is carried out one by one, and so that a part of 1st non-magnetic layer film or a part of free magnetic layer may be exposed A part of the 1st ferromagnetic layer membrane by which the laminating was carried out at least, 2nd non-magnetic layer film, 2nd ferromagnetic layer membrane, and antiferromagnetism layer membrane are deleted. The 1st ferromagnetic layer membrane by which laminating membrane formation was carried out before forming the laminating length bias layer of a right-and-left couple, The direction of each magnetization of the fixed magnetic layer which constitutes the 2nd ferromagnetic layer membrane and magnetoresistance-effect element It is characterized by adding heat treatment to the antiferromagnetism layer of the antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and a magnetoresistance-effect element. Moreover, invention of this invention according to claim 39 so that the upper surface of the free magnetic layer at the topmost part of a magnetoresistance-effect element may be worn After laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, an antiferromagnetism layer membrane, and the electrode lead layer membrane is carried out one by one, and so that some non-magnetic layer films or a part of free magnetic layer may be exposed A part of ferromagnetic layer membrane by which the laminating was carried out at least, antiferromagnetism layer membrane, and electrode lead layer membrane are deleted. Before forming the laminating length bias layer and electrode lead layer of a right-and-left couple, respectively The direction of each magnetization of the fixed magnetic layer which constitutes the ferromagnetic layer membrane and magnetoresistance-effect element by which laminating membrane formation was carried out It is characterized by adding heat treatment to the aforementioned antiferromagnetism layer of the antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and a magnetoresistance-effect element. Moreover, invention of this invention according to claim 40 so that the upper surface of the free magnetic layer at the topmost part of a magnetoresistance-effect element may be worn After laminating membrane formation of the 1st non-magnetic layer film, the 1st ferromagnetic layer membrane, the 2nd non-magnetic layer film, the 2nd ferromagnetic layer membrane, an antiferromagnetism layer membrane, and the electrode lead layer membrane is carried out one by one, and so that a part of 1st non-magnetic layer film or a part of free magnetic layer may be exposed A part of the 1st ferromagnetic layer membrane by which the laminating was carried out at least, the 2nd non-magnetic layer film, 2nd ferromagnetic layer membrane, antiferromagnetism layer membrane, and electrode lead layer membrane are deleted. Before forming the laminating length bias layer and electrode lead layer of a right-and-left couple, respectively The direction of each magnetization of the fixed magnetic layer which constitutes the 1st ferromagnetic layer membrane, the 2nd ferromagnetic layer membrane, and magnetoresistance-effect element by which laminating membrane formation was carried out It is characterized by adding heat treatment to the antiferromagnetism layer of the antiferromagnetism layer membrane by which laminating membrane formation was carried out so that it might become in each predetermined direction, and a magnetoresistance-effect element. Invention of this invention according to claim 41 on moreover, the upper surface which the free magnetic layer at the topmost part of the electrode lead layer of a right-and-left couple and a magnetoresistance-effect element or the non-magnetic layer film exposed The cap layer, the electrode lead layer of a right-and-left couple which were formed after the cap layer was formed, Patterning of the laminating length bias layer and magnetoresistance-effect element of a right-and-left couple is carried out to a predetermined configuration, and they are shaved off. Before an up gap insulating layer is formed, the direction of each magnetization of the fixed magnetic layer which constitutes the ferromagnetic and magnetoresistance-effect element which constitute a laminating length bias layer It is characterized by adding heat treatment to the antiferromagnetism layer of the antiferromagnetism layer membrane which constitutes a laminating length bias layer so that it may become in each predetermined direction, and a magnetoresistance-effect element. Each heat treatment for setting up so that the direction of each magnetization of the free magnetic layer combined by th ferromagnetic of the fixed magnetic layer which constitutes a magnetoresistance-effect element, and a laminating length bias layer, and the strong switched connection magnetic field may become in the predetermined direction can carry out continuously efficiently. again The magnetization in the end face of the ferromagnetic of the laminating length bias layer formed in the predetermined configuration will also gather in the same direction in line by methods, such as tching or patterning. It has the operation of the ability to make it join together by the free magnetic layer which countered through the nonmagnetic membrane, and the stable switched connection magnetic field.

[0025] Hereafter, the gestalt of operation of this invention is explained using a drawing.

[0026] (Gestalt 1 of operation) Drawing 1 is the explanation schematic diagram showing the gestalt 1 of operation of this invention, and is drawing in which it was typically shown near [which was seen from the head sliding-surface side which counters a magnetic-recording medium] the magnetoresistance-effect element.

[0027] In drawing 1 (a) A permalloy, Soft magnetic materials, such as Co system amorphous magnetic film or Fe system particle magnetic film, on the lower gap insulating layer (not shown) using the nonmagnetic insulating material of aluminum2O3 formed on lower shield layer (not shown) made from, AlN, or SiO2 grade IrMn, The antiferromagnetism layer 1, NiFe system alloy film which are material, such as alphaFe 2O3, a FeMn system alloy film, and a PtMn system alloy film The magnetoresistance-effect element 5 (MR element or GMR element.) which consisted of the nonmagnetic conductive layer 3 and the fixed magnetic layer 2 made from the fixed magnetic layer 2 made from Co, a CoFe alloy film, etc., Cu, etc., and a free magnetic layer 4 made from the same ferromagnetic material a following and GMR element -- saying -- it is constituted On furthermore, the upper surface of the free magnetic layer 4 which constitutes the GMR element 5 Antiferromagnetism material using the same material as the antiferromagnetism layer 1 which constitutes the nonmagnetic membrane 6 using non-magnetic materials, such as Ru of a right-and-left couple, the ferromagnetic 7 using the same material as the free magnetic layer 4 which constitutes the GMR element 5 on it, and th GMR element 5, respectively (depending on the case) the direction which does not use metal oxide -- being good -- the laminating length bias layer 9 of a right-and-left couple which consists of a used antiferromagnetism film 8 is constituted The direction of magnetization of a ferromagnetic 7 is arranged in the fixed direction, and is maintained at the state where it was stabilized by the switched connection magnetic field with the antiferromagnetism film 8. Therefore, the direction of magnetization of the free magnetic layer 4 which counters a ferromagnetic 7 through a nonmagnetic membrane 6 will maintain the state where it was stabilized very much in the same direction or the reverse direction corresponding to the thickness of the intervening nonmagnetic membrane 6. Furthermore, the electrode lead layer 10 of a right-and-left couple using material, such as Cu, Cr, or Ta, is like the conventional example on them. Although not moreover illustrated, an up gap insulating layer is formed using the same insulating material as a lower gap insulating layer so that the whole may be covered. Furthermore, an up shield layer is formed on it using the same soft

magnetic materials as a lower shield layer, and the magnetoresistance-effect type thin film magnetic head for the reproducing heads is constituted.
[0028] In addition, it cannot be overemphasized that a cap layer is formed by being made from Ta etc., and you may make it prevent oxidization so that the upper surface of the portion which the electrode lead layer 10 of a right-and-left couple and the free magnetic layer 4 exposed may be worn.
[0029] A magnetic field is given in the direction of Y, it is heat-treated in predetermined temperature and predetermined time (annealing), and the direction of magnetization of the fixed magnetic layer 2 is fixed in the direction of Y by the switched connection magnetic field with the antiferromagnetism layer 1 so that the direction of magnetization of the fixed magnetic layer 2 which constitutes the GMR element 5 may become in the head sliding surface which counters a magnetic-recording medium, and the direction Y (direction perpendicular to the space of drawing 1) which goes direct. It is made to become towards magnetization of the direction of magnetization of the ferromagnetic 7 of the right-and-left couple which constitutes the laminating length bias layer 9 of the fixed magnetic layer 2 on the other hand in the direction (for it to set to drawing 1 and for them to be X or the direction of -X) which carried out abbreviation nonstop. It is required to select and use the material of the antiferromagnetism film 8 which can set up the direction of magnetization on the conditions on which at least one condition differs from the setups of th direction of magnetization of the fixed magnetic layer 2 among the conditions of the magnetic field strength for setting up the direction of magnetization of a ferromagnetic 7, heat treatment temperature, or the processing time.
[0030] Furthermore, generate a ferromagnetic 7 and a strong switched connection magnetic field, and so that, as for the direction of magnetization of a ferromagnetic 7, the direction of magnetization of an opposite direction may be given to the free magnetic layer 4 The thickness of the thickness of the nonmagnetic membrane 6 of the right-and-left couple which constitutes the laminating length bias layer 9 of a right-and-left couple is set up, and the direction of magnetization of the free magnetic layer 4 (in for example, the case of the direction of X) is carried out in the direction of magnetization of a ferromagnetic 7, and the direction of magnetization of an opposite direction (the direction of -X). If th thickness of a nonmagnetic membrane 6 is small, the direction of magnetization of the free magnetic layer 4 is still the same direction as the direction of magnetization of a ferromagnetic 7 and the thickness of another side and a nonmagnetic membrane 6 is too large, by thickness, the direction of magnetization of the free magnetic layer 4 will change periodically with the direction where the direction of magnetization is the same, or a reverse direction, and will also decreas magnetic field strength gradually as it becomes again in the direction of origin, i.e., the same direction as Therefore, it is necessary to set the thickness of a nonmagnetic membrane 6 as the suitable range. According to the examination result, the thickness of a nonmagnetic membrane 6 changed with non-magnetic materials to be used, and obtained the result like Table 1.
[0031]
[Table 1]

使用する非磁性材料	磁化の方向を反対の向きにする膜厚
Ｒｕ	０．４～０．８ｎｍ
Ｃｕ	０．９ｎｍ近傍、２．０ｎｍ近傍
Ａｇ，Ａｕ	２～３ｎｍ
Ｉｒ	１．３ｎｍ近傍

[0032] Moreover, as shown in drawing 1 (b), the cap layer 11 may be formed using non-magnetic materials, such as Ta which is in contact with the upper surface of the free magnetic layer 4 which is between the laminating length bias layers 9 of the right-and-left couple in the gestalt 1 of the above-mentioned operation, and is in the topmost part of the magnetoresistance-effect element 5.
[0033] According to the gestalt 1 of this operation, as mentioned above as a vertical bias layer which gives the direction of magnetization to a free magnetic layer The laminating of a ferromagnetic and the antiferromagnetism film is carri d out as composition used as the laminating length bias layer which carried out the laminating of the nonmagnetic m mbrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple, respectively. by the switched connection magnetic field with an antiferromagnetism film By constituting the free magnetic layer which counters a ferromagnetic through the nonmagnetic membrane which the direction of magnetization of a ferromagnetic was arranged in the fixed direction (for example, the direction of -X), and was formed by suitable thickness As compared with the case where the laminating of the direct antiferromagnetism material is carried out to a free magnetic layer, the direction of magnetization of a free magnetic layer (for example, the direction of X) is fixed more strongly. by one side Th portion of the free magnetic layer which constitutes the GMR element between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple It is stabilized, becomes easy to be suitable in the direction of X, and will become very stable, and there can be little generating of a Barkhausen noise, r production sensitivity can be high, and reproducibility ability can be stabilized.
[0034] (Gestalt 2 of operation) Drawing 2 is the explanation schematic diagram showing the gestalt 2 of operation of this invention, and is the ** type view near the magnetoresistance-effect element seen from the head sliding-surface sid which counters a magnetic-recording medium.
[0035] In drawing 2 (a), like the gestalt 1 of the above-mentioned operation, laminating membrane formation of the antiferromagnetism layer 1, the fixed magnetic layer 2, the nonmagnetic conductive layer 3, and the free magnetic layer 4 is carried out one by one, and the GMR element 5 is formed on the lower gap insulating layer (not shown) formed on the l wer shield layer (not shown). Furthermore, on it, using the same material as the gestalt 1 of the above-mentioned operation, laminating membrane formation of the 1st nonmagnetic membrane 2001, 1st f rromagnetic 2002, 2nd nonmagnetic membrane 2003, 2nd ferromagnetic 2004, and antiferromagnetism film 2005 of a right-and-left couple is carried out one by one, respectively, and the laminating length bias layer 21 of a right-and-left couple is formed. In addition, it is the same as the gestalt 1 of operation for the direction of magnetization to become in the same direction of the 1st ferromagnetic 2002, the free magnetic layer 4 and the 1st ferromagnetic 2002, and the 2nd ferromagnetic 2004 which adjoin them by the thickness of the 1st nonmagnetic membrane 2001 and the 2nd nonmagnetic membrane 2003, or to become in the reverse direction. Moreover, like the gestalt 1 of operation, on the electrode lead layer 22 and the exposed GMR element 5, on the laminating length bias layer 21 of a right-and-left couple, the electrode lead

layer 22 of a right-and-left couple is formed, an up gap insulating layer (not shown) is formed, an up shield layer (not shown) is formed on it, and the magnetoresistance-effect type thin film magnetic head for the reproducing heads is formed further.

[0036] Moreover, as shown in drawing 2 </A> (b) It is between the laminating length bias layers 21 of a right-and-left couple which consist of the 1st nonmagnetic membrane 2001, 1st ferromagnetic 2002, 2nd nonmagnetic membrane 2003, 2nd ferromagnetic 2004, and antiferromagnetism film 2005 of a right-and-left couple. each in the gestalt 2 of the above-mentioned operation -- The cap layer 23 may be formed so that the upper surface of the free magnetic layer 4 which constitutes the magnetoresistance-effect element 5 may be touched.

[0037] According to the gestalt 2 of this operation, as mentioned above by there being the same effect as the gestalt 1 of the above-mentioned operation, and carrying out membrane formation formation of the antiferromagnetism film on th 2nd ferromagnetic By the switched connection magnetic field between the 2nd ferromagnetic and an antiferromagnetism film, the direction of magnetization of the 2nd ferromagnetic is arranged in the fixed direction. And th direction of magnetization of the 1st ferromagnetic which counters the 2nd ferromagnetic of a right-and-left couple through the 2nd nonmagnetic membrane of the right-and-left couple which has suitable thickness is arranged with the 2nd direction and opposite direction of magnetization of a ferromagnetic. Furthermore, by making the 1st ferromagnetic counter through the 1st nonmagnetic membrane formed by suitable thickness, and constituting a free magnetic layer It compares with the case where the laminating of the direct antiferromagnetism material is carried out to a free magnetic layer. The direction of magnetization of a free magnetic layer (For example, the direction of X) is fixed more strongly, and the direction of magnetization of the free magnetic layer of the portion which has countered the 1st ferromagnetic of a right-and-left couple becomes what was stabilized very much. The direction of magnetization of the portion of the free magnetic layer between the portions of the free magnetic layer which has countered the 1st ferromagnetic of a right-and-left couple is also stabilized, and become easy to be suitable in the same direction. Furthermore, by making it counter with the 1st ferromagnetic and the 2nd ferromagnetic through the 2nd nonmagnetic membrane as a laminating length bias layer, and making it the thickness of the 2nd nonmagnetic membrane so that the direction of each other magnetization may become in the reverse direction The 1st ferromagnetic and 2nd ferromagnetic will negate the leakage magnetic field by end-face magnetic charge mutually. And it prevents the direction of the magnetization by the anti-magnetic field in the end face of a ferromagnetic inclining in the direction of Y, and magnetization of a ferromagnetic will also gather to an edge, becomes the stable high sensitivity thing to an external magnetic field, and can make reproducibility ability stability further.

[0038] In addition, in the gestalten 1 and 2 of the above-mentioned operation, although the fixed magnetic layer and the fr e magnetic layer are described to be formed with a respectively single material, as shown in drawing 2 (c), they may be the laminating fixed magnetic layer 24 which consists a fixed magnetic layer of the 1st fixed magnetic layer film 2006, the 1st non-magnetic layer film 2007, and the 2nd fixed magnetic layer film 2008. Although the direction of magnetization of the fixed magnetic layer film which counters through the non-magnetic layer film by the thickness of the non-magnetic layer film which intervenes between fixed magnetic layer films at this time becomes in the respectively same direction or turns into an opposite direction, you have to set up the thickness of a non-magnetic layer film so that it may become in the reverse direction. Moreover, as shown in drawing 2 (d), they are the free magnetic layer film 2011 of the free magnetic layer 1st, and the 2nd free magnetic layer film 2012..... The free magnetic layer film which consists of the n-th free magnetic layer film 2013, and adjoins each other mutually may be the laminating free magnetic layer 25 using soft magnetic materials of a different kind.

[0039] (Form 3 of operation) Drawing 3 - drawing 11 are outline explanatory drawings showing the form 3 of operation of this invention, are process outline explanatory drawing for explaining the manufacturing process of the magnetoresistance-effect type thin film magnetic head for reproduction, and are the cross section cut in respect of being parallel to a head sliding surface [near the head sliding surface which counters a magnetic-recording medium]. Hereafter, the manufacture method of the magnetoresistance-effect type thin film magnetic head for reproduction is explained in order of each process using a drawing.

[0040] As shown in drawing 3 , membranes are formed on the substrate 30 made from AlTiC etc., and the nonmagnetic insulating material of aluminum2O3, AlN, or SiO2 grade is used on the lower shield layer 31 made from soft magnetic materials, such as a permalloy, Co system amorphous magnetic film, or Fe system particle magnetic film, and the lower gap insulating layer 32 is formed.

[0041] As shown in drawing 4 (a), as the 1st process on the lower gap insulating layer 32 As the antiferromagnetism lay r 41 is formed using material, such as an IrMn system, alphaFe2O3, NiO, a FeMn system alloy film, a NiMn system alloy film, or a PtMn system alloy film, and it is further shown in drawing 4 (b) Moreover, the fixed magnetic layer 42 is formed by being made from a NiFe system alloy film, Co, or a CoFe alloy film. Next, as shown in drawing 4 (c), the nonmagn tic conductive layer 43 made from Cu etc. is formed on the fixed magnetic layer 42. Furthermore, as shown in drawing 4 (d), on the nonmagnetic conductive layer 43, the free magnetic layer 44 is formed using the same material as th fix d magnetic layer 42, and the GMR element 45 by which laminating membrane formation of the antif rromagnetism layer 41, the fixed magnetic layer 42, the nonmagnetic conductive layer 43, and the free magnetic layer 44 was carried out one by one by the thin film is formed.

[0042] As the 2nd process, as shown in drawing 5 (a), the mushroom type resist 51 is formed on the GMR element 45, on the free magnetic layer 44 which constitutes the GMR element 45, non-magnetic materials, such as Ru, are used and the nonmagnetic membrane 52 of a right-and-left couple is formed. In addition, the thickness of the nonmagnetic membrane 52 at this time forms membranes by the thickness of the nonmagnetic membrane 52 of a right-and-left couple from which membranes are formed at a back process and the direction of magnetization of the free magnetic layer 44 turns into the direction of magnetization of a ferromagnetic, and an opposite direction by the switched connection magnetic field with the ferromagnetic magnetized. Furthermore, the ferromagnetic 53 of a right-and-left couple is formed on it using the same material as the free magnetic layer 44 which constitutes the GMR element 45. Furthermore, the material same on it as the antiferromagnetism layer 41 of the GMR lement 45 (how ver, it is better not to use a metal oxide film depending on the case) It uses, membrane formation formation of the antiferromagnetism film 54 of a right-and-left couple is carried out, and the laminating length bias layer 55 of the right-and-left couple which consists of the nonmagnetic membranes 52, the ferromagnetics 53, and the antiferromagnetism films 54 of a right-and-left couple, respectively is formed. In addition, it is necessary to set the material of the antiferromagnetism film 54 used as the material of the heat treatment conditions (magnetic field strength, heat treatment temperature, or heat treatment time) of the antiferromagnetism layer 41 which orients magnetization with the fixed magnetic layer 42 which constitutes the GMR element 45 from which any one condition differs at least at this time.

[0043] As the 3rd process, as shown in drawing 5 (b), on the antiferromagnetism film 54 of a right-and-left couple, non-magnetic materials, such as Cu, Cr, or Ta, are used, and the electrode lead layer 56 of a right-and-left couple is formed.
[0044] As shown in drawing 6 (a), in order to prevent oxidization of the free magnetic layer 44 equivalent to the portion which the GMR element 45 exposed on the portion which the electrode lead layer 56 of a right-and-left couple and the GMR element 45 exposed and to raise corrosion resistance as the 4th process, the cap layer 61 is formed with material, such as Ta.
[0045] Next, as shown in drawing 6 (b), on them, the up gap insulating layer 62 is formed using the same insulating material as the lower gap insulating layer 32, further, as shown in drawing 6 (c), on the up gap insulating layer 62, membrane formation formation of the up shield layer 63 is carried out using the same soft magnetic materials as the lower shield layer 31, and the magnetoresistance-effect type thin film magnetic head 64 for reproduction is formed.
[0046] In addition, heat treatment (annealing processing) which sets up the direction of each magnetization of the ferromagnetic which constitutes the fixed magnetic layer or laminating length bias layer which constitutes a GMR element After forming the cap layer 61 so that the electrode lead layer 56 of a right-and-left couple may be formed and a it top may be covered, It is desirable to carry out in the stage before carrying out patterning of the GMR element 45, the laminating length bias layer 55 of a right-and-left couple, the electrode lead layer 56 of a right-and-left couple, and the cap layer 61 to a predetermined configuration and being shaved off. namely, the head sliding surface which counters a magnetic-recording medium after the 4th process end and the direction (direction perpendicular to the space of drawing 6 (a)) of Y which goes direct -- a magnetic field -- in addition, at predetermined temperature, annealing (heat treatment) is carried out by the predetermined time, and the direction of magnetization of the fixed magnetic layer 42 is fixed in the direction of Y by the switched connection magnetic field with the antiferromagnetism layer 41 Moreover, the direction which intersects perpendicularly towards magnetization of the fixed magnetic layer 42 (the direction of Y) Add a magnetic field in (for example, the direction of -X), and it heat-treats on the heat treatment conditions which set up the direction of magnetization of the fixed magnetic layer 42, and different conditions (annealing). Without affecting it towards magnetization of the fixed magnetic layer 42, it is made to intersect perpendicularly towards magnetization of the direction of magnetization of a ferromagnetic 53 of the fixed magnetic layer 42, and is made to become the direction of magnetization of the direction of magnetization of the free magnetic layer 44 of a ferromagnetic 53, and an opposite direction (the direction of X) by the switched connection magnetic field with a ferromagnetic 53. Moreover, the sequence of heat treatment (annealing processing) of setting up the direction of each magnetization of the ferromagnetic of a fixed magnetic layer or a laminating length bias layer may process first which magnetic film of a fixed magnetic layer or a ferromagnetic.
[0047] In addition, in the 1st above-mentioned process, as shown in drawing 2 (c), you may form the laminating fixed magnetic layer 24 which carried out laminating membrane formation of the 1st fixed magnetic layer film 2006, the 1st non-magnetic layer film 2007, and the 2nd fixed magnetic layer film 2008 for the fixed magnetic layer one by one, and carried out the laminating of the fixed magnetic layer film of two or more layers through the non-magnetic layer film. Moreover, as shown in drawing 2 (d), it cannot be overemphasized that laminating membrane formation may be carried out using the material of the free magnetic layer film 2011 of the free magnetic layer 1st, the 2nd free magnetic layer film 2012, ..., different species [magnetic layer / free / which adjoins each other mutually like the n-th free magnetic layer film 2013], and the laminating free magnetic layer 25 may be formed.
[0048] Moreover, after cleaning the upper surface of the free magnetic layer 44 formed by the topmost part of the GMR element 45 as the 2nd above-mentioned process after forming the mushroom type resist 51 by methods, such as a pulley spatter by Ar etc., or efficient consumer response, and removing the oxide film of the front face of the free magnetic layer 44, the residue of a resist, a foreign matter, or dirt, the nonmagnetic membrane 52 of a right-and-left couple is formed on the free magnetic layer 44 of the GMR element 45. Next, on it, form the ferromagnetic 53 of a right-and-left couple, and membrane formation formation of the antiferromagnetism film 54 of a right-and-left couple is carried out further at the ferromagnetic 53 top of a right-and-left couple. By forming the laminating length bias layer 55 of the right-and-left couple which consists of the nonmagnetic membranes 52, the ferromagnetics 53, and the antiferromagnetism films 54 of a right-and-left couple, respectively A foreign matter can be lost between a laminating length bias layer and a free magnetic layer, the fall of a switched connection magnetic field can be inhibited, and a strong switched connection magnetic field can be maintained.
[0049] Moreover, as the 2nd process, as shown in drawing 7 (a), the ferromagnetic layer membrane 702 is formed using th same material as the free magnetic layer 44 which forms the non-magnetic layer film 701 by the thickness which fulfilled the conditions of the thickness of the above-mentioned nonmagnetic membrane using non-magnetic materials, such as Ru, next constitutes the GMR element 45 on the upper surface of the non-magnetic layer film 701 so that the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 may be worn. Furthermore, laminating membrane formation of the antiferromagnetism layer membrane 703 is carried out using the material (however, it is better not to use a metal oxide film depending on the case) same on the upper surface of the ferromagnetic layer membrane 702 as the antiferromagnetism layer 41 of the GMR element 45. A photoresist is applied. next, by methods, such as dry etching It is deleted so that the upper surface of the free magnetic layer 44 where the non-magnetic layer film 701, the ferromagnetic layer membrane 702, and the antiferromagnetism layer membrane 703 by which the laminating was carried out constitute the GMR element 45 may be exposed, as shown in drawing 7 (b). The nonmagnetic membrane 71, the ferromagnetic 72, and the antiferromagnetism film 73 of a right-and-left couple are formed, respectively, and the laminating length bias layer 74 of the right-and-left couple which consists of the nonmagnetic membranes 71, the ferromagnetics 72, and the antiferromagnetism films 73 of a right-and-left couple, respectively is formed. In addition, the ferromagnetic layer membrane 702 and the antiferromagnetism layer membrane 703 are deleted at least, and the non-magnetic layer film 701 may be made to be exposed by methods, such as dry etching. It is desirable to perform it, after carrying out laminating membrane formation of the non-magnetic layer film 701, the ferromagnetic layer membrane 702, and the antiferromagn tism layer membrane 703 one by one, and before heat treatment for setting the direction of magnetization as the free magnetic layer by the switched connection magnetic field with the ferromagnetic which constitutes the fixed magnetic layer in this case and a laminating length bias layer is deleted so that the upper surface of the non-magnetic layer film 701 or the free magnetic layer 44 may be exposed by methods, such as dry etching. Next, as the 3rd process, as shown in drawing 7 (c), the electrode lead layer membrane 705 is formed so that the whole may be covered on the portion which the antiferromagnetism film 73 of a right-and-left couple and the GMR element 45 exposed, a photoresist may be applied, the electrode lead layer membrane 705 may be deleted by methods, such as dry etching, and the electrode lead layer 75 may be formed after

that. moreover, it is shown in drawing 7 (d) — as — a mushroom — a type resist (not shown) may be formed and membrane formation formation of the electrode lead layer 76 may be carried out Other processes can also produce the magnetoresistance-effect type thin film magnetic head for reproduction using the same process as the above-mentioned process.

[0050] Moreover, as the 2nd process, as shown in drawing 8 , so that the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 may be worn The type resist 82 is formed. the mushroom after forming a nonmagnetic membrane 81 by the thickness which fulfilled the conditions of the thickness of the above-mentioned nonmagnetic membrane using non-magnetic materials, such as Ru, — Membrane formation formation of the ferromagnetic 83 and the antiferromagnetism film 84 of a right-and-left couple may be carried out one by one, respectively, and the laminating length bias layer 85 of a right-and-left couple which consists of a nonmagnetic membrane 81, a ferromagnetic 83 of a right-and-left couple, and an antiferromagnetism film 84 of a right-and-left couple may be formed.

[0051] moreover, the 2nd above-mentioned process — setting — a mushroom — as the 3rd process, as shown in drawing 9 (a), after the antiferromagnetism film 54 of a right-and-left couple is formed using a type resist the mushroom — the portion top which deleted the type resist and the antiferromagnetism film 54 of a right-and-left couple and the GMR element 45 exposed — the whole — a wrap, as the electrode lead layer membrane 91 is formed like and it is shown in drawing 9 (b) after that A photoresist may be applied, a part of electrode lead layer membrane 91 may be deleted by methods, such as dry etching, and the electrode lead layer 92 of a right-and-left couple may be formed so that a part of GMR element 45 may be exposed. Moreover, as shown in drawing 9 (c) The electrode lead layer membrane 95 is formed like. the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 from other examples of the 2nd above-mentioned process — a wrap — each which was formed by the upper surface of the nonmagnetic membrane 93 formed like — the portion which the antiferromagnetism film 94 of a right-and-left couple and the nonmagnetic membrane 93 exposed — a wrap — after that A photoresist may be applied, by methods, such as dry etching, a part of electrode lead layer membrane 95 may be deleted so that a part of nonmagnetic membrane 93 or GMR element 45 may be exposed, and you may form the electrode lead layer 96 of a right-and-left couple.

[0052] moreover, the mushroom formed at the 2nd process as the 3rd process as shown in drawing 10 (a) — another mushroom after removing a type resist — a part of portion which formed the type resist and the antiferromagnetism film 54 of a right-and-left couple and the GMR element 45 exposed — a wrap — it may be made like and the electrod lead layer 101 of a right-and-left couple may be formed moreover, the mushroom formed at the 2nd process as shown in drawing 10 (b) — another mushroom after removing a type resist — a part of portion which the nonmagnetic membrane 102 which formed the type resist and was formed on the antiferromagnetism film 103 of a right-and-left couple and the GMR element 45 exposed — a wrap — it may be made like and the electrode lead layer 104 of a right-and-left couple may be formed in addition, the mushroom formed at the 2nd process as the 3rd process as shown in drawing 10 (c) — the exposed antiferromagnetism layer [after removing a type resist] 54, and GMR element 45 top — a wrap — like another mushroom on a part of the upper surface of the cap layer which forms the cap layer 105 mad from Ta etc., and is on the GMR element 45 — a type resist (not shown) may be formed and the electrode lead layer 106 of a right-and-left couple may be formed The type resist 82 is formed. moreover, the mushroom after the nonmagnetic membrane 81 was formed on the GMR element 45 as in drawing 8 — the portion which the antiferromagnetism film and the nonmagnetic membrane exposed like the above-mentioned although it did not illustrate when the ferromagnetic 83 and the antiferromagnetism film 84 of a right-and-left couple were formed, respectively — a wrap — like — a cap layer — forming membranes — another mushroom on it — a type resist may be formed and the electrode lead layer of a right-and-left couple may be formed

[0053] Moreover, in the 2nd above-mentioned process and the 3rd process, as the 2nd process, as shown in drawing 7 (a) As laminating membrane formation of the non-magnetic layer film 701, the ferromagnetic layer membrane 702, and the antiferromagnetism layer membrane 703 is carried out one by one and it is shown in drawing 11 (a) as the 3rd proc ss so that the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 may be worn Furthermore, after forming the electrode lead layer membrane 1101 on it, as shown in drawing 11 (b) So that a part of non-magnetic layer film 701 or free magnetic layer 44 may be exposed Apply a photoresist and the electrode lead layer m mbrane 1101, the antiferromagnetism layer membrane 703, and the ferromagnetic layer membrane 702 are shaved off at least by methods, such as dry etching. On the free magnetic layer 44, you may form the laminating length bias lay r 114 of a right-and-left couple which consists of the nonmagnetic membrane 111, the ferromagnetic 112, and the antiferromagnetism film 113 of a right-and-left couple, respectively, and the electrode lead layer 115 of a right-and-l ft couple. Also in this case, as for heat treatment (annealing processing) which adds the direction of predetermined magn tization to each of the fixed magnetic layer of a GMR element, and a free magnetic layer, it is desirable to carry out, after laminating membrane formation of a non-magnetic layer film, a ferromagnetic layer membrane, an antiferromagnetism layer membrane, and the electrode lead layer membrane is carried out, and before being deleted by dry tching etc.

[0054] According to the gestalt of this operation, as mentioned above as a vertical bias layer which gives the direction of magnetization to a free magnetic layer The laminating of the antiferromagnetism film is carried out on the ferromagnetic of a right-and-left couple as composition used as the laminating length bias layer which carried out the laminating of the nonmagnetic membrane, ferromagnetic, and antiferromagnetism film of a right-and-left couple, resp ctively. by the switched connection magnetic field between a ferromagnetic and an antiferromagnetism film The nonmagnetic membrane of the right-and-left couple which was arranged in the direction (for example, the direction of -X) where the direction of magnetization of a ferromagnetic is fixed, and was formed by suitable thickness is minded. - Fre Magnetic Layer Which Has Countered Ferromagnetic of Right-and-Left Couple Magnetized in the Direction of X Sets into the Portion Which Has Countered. A free magnetic layer holds the direction of magnetization (the direction of X) strongly by the switched connection magnetic field with a ferromagnetic still stronger than the case of the free magnetic layer which touched the antiferromagnetism film directly, and it is one side. The portion of the free magnetic layer which constitutes the GMR element between the free magnetic layers of the right and left which have countered the ferromagnetic of a right-and-left couple It is stabilized and becomes easy to be suitable in the direction of X, and there is little generating of a Barkhausen noise and it can produce the magnetoresistance-effect type thin film magnetic head for reproduction which has the reproducibility ability stabilized very much.

[0055] (Gestalt 4 of operation) Drawing 12 - drawing 19 are outline explanatory drawings showing the gestalt 4 of operation of this invention, and are the cross section cut in respect of being parallel to a head sliding surface [near the

head sliding surface which counters a magnetic-recording medium] like the gestalt 3 of the above-mentioned operation. Hereafter, the manufacture method of the magnetoresistance-effect type thin film magnetic head for reproduction is explained in order of each process using a drawing.
[0056] Like the form 3 of the above-mentioned operation, as the 1st process, as are shown in drawing 4 (a), and the antiferromagnetism layer 41 is formed and it is further shown on the lower gap insulating layer 32 at drawing 4 (b), the fixed magnetic layer 42 is formed on it. Next, as shown in drawing 4 (c), on the fixed magnetic layer 42, the nonmagnetic conductive layer 43 is formed, further, as shown at drawing 4 (d), the free magnetic layer 44 is formed on the nonmagnetic conductive layer 43, and the GMR element 45 by which laminating membrane formation of the antiferromagnetism layer 41, the fixed magnetic layer 42, the nonmagnetic conductive layer 43, and the free magnetic layer 44 was carried out one by one by the thin film is formed.
[0057] next, it is shown in drawing 12 (a) as the 2nd process -- as -- a mushroom -- the type resist 121 is formed and the 1st nonmagnetic membrane 122 of a right-and-left couple is formed on the free magnetic layer 44 which constitutes the GMR element 45 In addition, the thickness of this nonmagnetic membrane 122 is the same as that of the gestalt 3 of the above-mentioned operation. Furthermore, as shown in drawing 12 (b), the 1st ferromagnetic 123 of a right-and-left couple is formed on it. Furthermore, as shown in drawing 13 (a), the 2nd nonmagnetic membrane 131 is formed with the same material as the 1st nonmagnetic membrane 122 on the 1st ferromagnetic 123 of a right-and-left couple. Furthermore, the 2nd ferromagnetic 132 is formed on it using the same material as the 1st ferromagnetic 123. Next, as shown in drawing 13 (b), on the 2nd ferromagnetic 132, membrane formation formation of the antiferromagnetism film 133 is carried out, and the laminating length bias layer 134 of the right-and-left couple which consists of the 1st nonmagnetic membrane 122, 1st ferromagnetic 123, 2nd nonmagnetic membrane 131, 2nd ferromagnetic 132, and antiferromagnetism film 133 of a right-and-left couple, respectively is formed.
[0058] As the 3rd process, as shown in drawing 14 (a), like the gestalt 3 of operation, non-magnetic materials, such as Cu, Cr, or Ta, are used, and the electrode lead layer 141 of a right-and-left couple is formed on the antiferromagnetism film 133 of a right-and-left couple.
[0059] As shown in drawing 14 (b), in order to prevent oxidization of the free magnetic layer 44 equivalent to the portion which the GMR element 45 exposed on the portion which the electrode lead layer 141 of a right-and-left couple and the GMR element 45 exposed and to raise corrosion resistance as the 4th process, the cap layer 142 is formed with material, such as Ta.
[0060] In addition, you have to select the material used as an antiferromagnetism film 133 on the same conditions as the gestalt 3 of the above-mentioned operation. It is made to be the same as that of the gestalt 3 of the above-mentioned operation after forming the cap layer 142. In order to set up the direction of magnetization of the fixed magnetic layer 42 (the direction of Y), and the direction of magnetization of the free magnetic layer 44 in the direction (for example, the direction of -X) which intersects perpendicularly towards magnetization of the fixed magnetic layer 42 (the direction of Y) A magnetic field is given in each direction, it heat-treats in predetermined temperature and predetermined, predetermined time, respectively (annealing), and the direction of predetermined magnetization is given to a fixed magnetic layer and a laminating length bias layer, and a free magnetic layer.
[0061] After forming a type resist, the upper surface of the free magnetic layer 44 formed by the topmost part of the GMR element 45 is cleaned by methods, such as a pulley spatter by Ar etc., or efficient consumer response. moreover -- as the 2nd process -- a mushroom -- After removing the oxide film of the front face of the free magnetic layer 44, the residue of a resist, a foreign matter, or dirt, as shown in drawing 13 (b), on the free magnetic layer 44, the 1st nonmagnetic membrane 122 of a right-and-left couple is formed, and the 1st ferromagnetic 123 of a right-and-left couple is formed on it. Next, the 2nd nonmagnetic membrane 131 is formed on it, and the 2nd ferromagnetic 132 is formed on it. Furthermore, the strong switched connection magnetic field of the laminating length bias layer of a right-and-left couple and a free magnetic layer is acquired by carrying out membrane formation formation of the antiferromagnetism film 133 of a right-and-left couple, and forming the laminating length bias layer 134 of the right-and-left couple which consists of the 1st nonmagnetic membrane 122, 1st ferromagnetic 123, 2nd nonmagnetic membrane 131, 2nd ferromagnetic 132, and antiferromagnetism film 133 of a right-and-left couple, respectively.
[0062] Moreover, as the 2nd process, as shown in drawing 15 (a), so that the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 may be worn After carrying out laminating membrane formation of the 1st non-magnetic layer film 1501, the 1st ferromagnetic layer membrane 1502, the 2nd non-magnetic layer film 1503, the 2nd ferromagnetic layer membrane 1504, and the antiferromagnetism layer membrane 1505 one by one, as shown in drawing 15 (b) Apply a photoresist, and by methods, such as dry etching, so that the upper surface of the free magnetic layer 44 which constitutes the 1st non-magnetic layer film 1501 or GMR element 45 may be exposed The 1st ferromagnetic layer membrane 1502 by which the laminating was carried out at least, the 2nd non-magnetic layer film 1503, the 2nd ferromagnetic layer membrane 1504, and the antiferromagnetism layer membrane 1505 are deleted. The 1st nonmagnetic membrane 151, 1st ferromagnetic 152, 2nd nonmagnetic membrane 153, 2nd ferromagnetic 154, and antiferromagnetism film 155 of a right-and-left couple are formed, respectively. You may form the laminating length bias layer 156 of the right-and-left couple which consists of the 1st nonmagnetic membrane 151, 1st ferromagnetic 152, 2nd nonmagnetic membrane 153, 2nd ferromagnetic 154, and antiferromagnetism film 155 of a right-and-left couple, respectively. Also in this case, heat treatment (annealing processing) which sets up the direction of each magnetization of the ferromagnetic of a fixed magnetic layer or a laminating length bias layer After carrying out laminating membrane formation of the 1st non-magnetic layer film 1501, the 1st ferromagnetic layer membrane 1502, the 2nd non-magnetic layer film 1503, the 2nd ferromagnetic layer membrane 1504, and the antiferromagnetism layer membrane 1505 one by one And it is desirable to carry out, before the 1st non-magnetic layer film 1501 by which the laminating was carried out, the 1st ferromagnetic layer membrane 1502, the 2nd non-magnetic layer film 1503, the 2nd ferromagnetic layer membrane 1504, and the antiferromagnetism layer membrane 1505 are deleted by methods, such as dry tching.
[0063] Moreover, so that the upper surface of the free magnetic layer 44 which constitutes a GMR element may be worn as the 2nd process, as shown in drawing 16 The type resist 162 is formed. the mushroom after forming the 1st nonmagnetic membrane 161 -- Membrane formation formation of the 1st ferromagnetic 163, 2nd nonmagnetic membrane 164, 2nd ferromagnetic 165, and antiferromagnetism film 166 of a right-and-left couple is carried out one by one, respectively. You may form the laminating length bias layer 167 of a right-and-left couple which consists of the 1st nonmagnetic membrane 161, the 1st ferromagnetic 163 of a right-and-left couple, the 2nd nonmagnetic membrane 164, the 2nd ferromagnetic 165, and an antiferromagnetism film 166 of a right-and-left couple.
[0064] Moreover, like other examples in the form 3 of the above-mentioned operation, as the 3rd process, as shown in

drawing 17 (a) The electrode lead layer membrane 171 is formed like. a mushroom -- the portion top which the free magnetic layer 44 which deletes a type resist and constitutes the antiferromagnetism film 133 and GMR element of a right-and-left couple exposed -- the whole -- a wrap -- Then, a photoresist is applied, by methods, such as dry etching, delete a part of electrode lead layer membrane 171, it is made exposed [some upper surfaces of the free magnetic layer 44], and the electrode lead layer 172 of a right-and-left couple may be formed. The electrode lead layer membrane 173 is formed so that the upper surface [of a portion] and antiferromagnetism film 166 top which the 1st nonmagnetic membrane 161 formed so that the upper surface of the free magnetic layer 44 which constitutes the GMR element 45 from the 2nd process in other examples might be worn, as shown in drawing 17 (b) exposed may be covered. Moreover, after that, A photoresist may be applied, by methods, such as dry etching, a part of electrode lead layer membrane 173 may be deleted so that a part of 1st nonmagnetic membrane 161 or free magnetic layer 44 may be exposed, and you may form the electrode lead layer 174 of a right-and-left couple.

[0065] moreover, the mushroom formed at the 2nd process as the 3rd process as shown in drawing 18 (a) -- a type resist -- deleting -- another mushroom -- a part of portion which the free magnetic layer 44 which forms the type resist 181 and constitutes the antiferromagnetism film 133 and GMR element of a right-and-left couple exposed -- a wrap -- it may be made like and the electrode lead layer 182 of a right-and-left couple may be formed moreover, the mushroom formed at the 2nd process as shown in drawing 18 (b) -- a type resist -- deleting -- another mushroom -- a part of portion which the 1st nonmagnetic membrane 161 which formed the type resist 183 and was formed on the antiferromagnetism film 166 of a right-and-left couple and the free magnetic layer 44 exposed -- a wrap -- it may be made like and the electrode lead layer 184 of a right-and-left couple may be formed In addition, although not illustrated, as explained in other examples of the 3rd process in the gestalt 3 of the above-mentioned operation another mushroom -- the portion which the free magnetic layer 44 which constitutes the antiferromagnetism film 133 and GMR element of a right-and-left couple exposed before forming the type resist 181 -- a wrap -- like -- a cap layer -- forming m mbranes -- after and another mushroom -- the type resist 181 may be formed and the electrode lead layer 182 of a right-and-left couple may be formed moreover, another mushroom -- the portion top which the 1st nonmagnetic membrane 161 formed on the antiferromagnetism film 166 of a right-and-left couple and the free magnetic layer 44 exposed before forming the type resist 183 -- a wrap -- like -- a cap layer -- forming membranes -- after and another mushroom -- the type resist 183 may be formed and the electrode lead layer 184 of a right-and-left couple may be formed

[0066] Moreover, in the 2nd above-mentioned process and the 3rd process, as the 2nd process, as shown in drawing 19 Laminating membrane formation of the 1st non-magnetic layer film 1901, the 1st ferromagnetic layer membrane 1902, the 2nd non-magnetic layer film 1903, the 2nd ferromagnetic layer membrane 1904, and the antiferromagnetism layer membrane 1905 is carried out one by one so that the upper surface of the free magnetic layer 44 which constitutes a GMR element may be worn. Next, as the 3rd process, after forming the electrode lead layer membrane 1906 on it further, so that a part of free magnetic layer 44 may be exposed A photoresist is applied and the electrode lead layer membrane 1906, the antiferromagnetism layer membrane 1905, the 2nd ferromagnetic layer membrane 1904, the 2nd nonmagnetic membrane 1903, the 1st ferromagnetic 1902, and the 1st non-magnetic layer film 1901 are shaved off by methods, such as dry etching. on the free magnetic layer 44 You may form the laminating length bias layer 196 of a right-and-left couple which consists of the 1st nonmagnetic membrane 191, 1st ferromagnetic 192, 2nd nonmagnetic membrane 193, 2nd ferromagnetic 194, and antiferromagnetism film 195 of a right-and-left couple, respectively, and the electrode lead layer 197 of a right-and-left couple. In addition, at this time, you may shave off by methods, such as dry etching, so that the 1st non-magnetic layer film 1901 may be exposed. Also in this case, heat treatment (annealing processing) which sets up the direction of each magnetization of the ferromagnetic of a fixed magnetic layer or a laminating length bias layer After carrying out laminating membrane formation of the 1st non-magnetic layer film 1901, the 1st ferromagnetic layer membrane 1902, the 2nd non-magnetic layer film 1903, the 2nd ferromagnetic layer membrane 1904, the antiferromagnetism layer membrane 1905, and the electrode lead layer membrane one by one And it is desirable to carry out, before being deleted so that a photoresist may be applied and a part of free magnetic layer 44 may be exposed by methods, such as dry etching.

[0067] At the same time the same effect as the gestalt 3 of the above-mentioned operation is acquired as mentioned above according to the gestalt of this operation By choosing suitably the thickness of the 2nd nonmagnetic membrane of a laminating length bias layer, and making the direction of magnetization of the 1st ferromagnetic and the 2nd ferromagnetic into each other in the direction of a retrose The leakage magnetic field by the end-face magnetic charg of a ferromagnetic will be mutually negated by the 1st ferromagnetic and 2nd ferromagnetic. And it prevents the direction of the magnetization by the anti-magnetic field in the end face of a ferromagnetic inclining in the direction of Y. Magnetization of a ferromagnetic will also gather to an edge, becomes that by which the direction of magnetization of a free magnetic layer was stabilized more, and can produce the magnetoresistance-effect type thin film magnetic head for reproduction which has the reproducibility ability stabilized further.

[0068] (Gestalt 5 of operation) Drawing 20 - drawing 22 are outline explanatory drawings showing the gestalt 5 of op ration of this invention, are process outline explanatory drawing for explaining the manufacturing process of the magnetoresistance-effect type thin film magnetic head for reproduction, and are the cross section cut in respect of being parallel to a head sliding surface [near the head sliding surface which counters a magnetic-recording medium]. Hereafter, the manufacture method of the magnetoresistance-effect type thin film magnetic head for reproduction is explained in order of each process using a drawing.

[0069] As the 1st process, as shown in drawing 20 (a), on the GMR element 205 which laminating membrane formation was carried out and was formed, the antiferromagnetism layer 201, the fixed magnetic layer 202, the nonmagnetic conductive layer 203, and the free magnetic layer 204 use material, such as Ta, and form the cap layer 206 for antioxidizing of the free magnetic layer 204.

[0070] Next, as the 2nd process, as shown in drawing 20 (b), a part of cap layer 206 is deleted, on it, laminating membrane formation of the nonmagnetic membrane 2051, the ferromagnetic 2052, and th antiferromagnetism film 2053 of a right-and-left couple is carried out one by one, respectively, and the laminating length bias layer 208 of a right-and-left couple is formed so that the mushroom type resist 207 may be formed and a part of both-sides section of the free magnetic layer 204 of the GMR element 205 may be exposed.

[0071] As the 3rd process, as shown in drawing 20 (c), on the antiferromagnetism film 2053 of a right-and-left couple, non-magnetic materials, such as Cu, Cr, or Ta, are used, and the electrode lead layer 209 of a right-and-left couple is formed. Thus, the magnetoresistance-effect type thin film magnetic head for reproduction is producible.

[0072] moreover, the 2nd above-mentioned process is shown in drawing 21 -- as -- a mushroom -- so that the type

resist 210 may be formed and a part of both-sides section of the free magnetic layer 204 of a GMR element may be exposed A part of cap layer 206 is deleted, on it, the 1st nonmagnetic membrane 211, 1st ferromagnetic 212, 2nd nonmagnetic membrane 213, 2nd ferromagnetic 214, and antiferromagnetism film 215 of a right-and-left couple may be formed, respectively, and the laminating length bias layer 216 of a right-and-left couple may be formed.
[0073] Moreover, the fixed magnetic layer formed in the 1st process may be a laminating fixed magnetic layer which consists of a fixed magnetic layer which counters through a non-magnetic layer as shown in drawing 2 (c). Moreover, you may be the laminating free magnetic layer which the free magnetic layer which a free magnetic layer also adjoins turns into from two or more layers using soft magnetic materials of a different kind as shown in drawing 2 (d) similarly.
[0074] A type resist is deleted. moreover, it is shown in drawing 22 (a) as the 3rd process -- as -- a mushroom -- The electrode lead layer membrane 221 is formed so that the whole may be covered on the portion which the cap layer 206 formed on the free magnetic layer 204 which constitutes the antiferromagnetism film 2053 and GMR element of a right-and-left couple exposed. Then, a photoresist may be applied, a part of electrode lead layer membrane 221 may be deleted by methods, such as dry etching, and the electrode lead layer 222 of a right-and-left couple may be formed so that a part of cap layer 206 on the free magnetic layer 204 may be exposed.
[0075] The type resist 223 is formed. moreover, the mushroom formed at the 2nd process as the 3rd process as shown in drawing 22 (b) -- another mushroom after removing a type resist -- As a part of portion which the cap layer 206 formed on the free magnetic layer 204 which constitutes the antiferromagnetism film 2053 and GMR element of a right-and-left couple exposed is covered, you may form the electrode lead layer 224 of a right-and-left couple. In the case of the laminating length bias layer by which the laminating was carried out, the electrode lead layer of a right-and-left couple can be similarly formed by five layers which consist of the 1st nonmagnetic membrane, 1st ferromagnetic, 2nd nonmagnetic membrane, 2nd ferromagnetic, and antiferromagnetism film.
[0076] As mentioned above, according to the gestalt of this operation, the same effect as the gestalt 3 of the above-mentioned operation and the gestalt 4 of operation is acquired, it becomes that by which the direction of magnetization of a free magnetic layer was stabilized more, and the magnetoresistance-effect type thin film magnetic head for reproduction which has the reproducibility ability stabilized further can be produced.
[0077]
[Effect of the Invention] this invention as mentioned above on the free magnetic layer which constitutes a GMR element By forming the laminating length bias layer (three layers or five layers) of 1 time of the laminating of a nonmagnetic membrane and a ferromagnetic or 2 times of laminatings, and the antiferromagnetism film further formed on it The direction of the magnetization arranged in the fixed direction by the switched connection magnetic field with th antiferromagnetism layer which the ferromagnetic of a laminating length bias layer has on it is added. and The 2nd nonmagnetic membrane which has the free magnetic layer (in the case of three layers) or the suitable thickness of the ferromagnetic which countered through the nonmagnetic membrane which has thickness with a suitable laminating length bias layer, and a GMR element is minded. The switched connection magnetic field with the free magnetic layer (in the case of five layers) which countered through the 1st ferromagnetic which countered the 2nd ferromagnetic, and the 1st nonmagnetic membrane which has suitable thickness A very strong joint magnetic field is acquired as compared with the case of the free magnetic layer which touched the direct antiferromagnetism film. The direction of the magnetization stabilized very much by the free magnetic layer of the portion which countered the ferromagnetic through the nonmagnetic membrane is given. The free magnetic layer portion between the free magnetic layers of the right and left which countered the ferromagnetic through the nonmagnetic membrane It is stabilized in the same direction as the direction of magnetization of the free magnetic layer of the right and left which countered the ferromagnetic, and become easy to be suitable. Generating of a noise is small and it is very effective in the thin film magnetic head which has the ****** head gap length for reproducing the record signal which it is effective in good reproducibility ability with high reproduction sensitivity being realizable, and was especially formed into high recording density. Moreover, the thin film magnetic head of such outstanding reproducibility ability is easily producible.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The transverse-plane ****** type view of the thin film magnetic head showing the gestalt 1 of operation of this invention
[Drawing 2] The transverse-plane ****** type view of the thin film magnetic head showing the gestalt 2 of operation of this invention
[Drawing 3] The transverse-plane schematic diagram showing a part of manufacturing process of the thin film magnetic head in the gestalt 3 of operation of this invention
[Drawing 4] The transverse-plane schematic diagram showing the 1st process of the manufacturing process of the thin film magnetic head in the gestalt 3 of operation of this invention
[Drawing 5] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head and the 3rd process in the gestalt 3 of operation of this invention
[Drawing 6] The transverse-plane schematic diagram showing the 4th process of the manufacturing process of the thin film magnetic head in the gestalt 3 of operation of this invention, and the process of other parts
[Drawing 7] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head and the 3rd process in other examples of the gestalt 3 of operation of this invention
[Drawing 8] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 3 of operation of this invention
[Drawing 9] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 3 of operation of this invention
[Drawing 10] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 3 of operation of this invention
[Drawing 11] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 3 of operation of this invention
[Drawing 12] The transverse-plane schematic diagram showing a part of 2nd process of the manufacturing process of the thin film magnetic head which can set operation of this invention gestalt 4
[Drawing 13] The transverse-plane schematic diagram showing a part of other 2nd process of the manufacturing process of the thin film magnetic head which can set operation of this invention gestalt 4
[Drawing 14] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head and the 4th process that operation of this invention can be set gestalt 4
[Drawing 15] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 4 of operation of this invention
[Drawing 16] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 4 of operation of this invention
[Drawing 17] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 4 of operation of this invention
[Drawing 18] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 4 of operation of this invention
[Drawing 19] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 4 of operation of this invention
[Drawing 20] The transverse-plane schematic diagram showing the 1st process of the manufacturing process of the thin film magnetic head in the gestalt 5 of operation of this invention, the 2nd process, and the 3rd process
[Drawing 21] The transverse-plane schematic diagram showing the 2nd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 5 of operation of this invention
[Drawing 22] The transverse-plane schematic diagram showing the 3rd process of the manufacturing process of the thin film magnetic head in other examples of the gestalt 5 of operation of this invention
[Drawing 23] The tropia schematic diagram showing the conventional thin film magnetic head
[Drawing 24] The transverse-plane ****** type view showing the conventional thin film magnetic head
[D scription of Notations]
1 41,201,244 Antiferromagnetism layer
2 42,202,245 Fixed magnetic layer
3 43,203,246 Nonmagnetic conductive layer
4 44,204,247 Free magnetism
5 45,205,233 Magnetoresistance-effect element (GMR element)
6, 52, 71, 81, 93, 102, 111, 2051 Nonmagnetic membrane
7, 53, 72, 83, 112, 2052 Ferromagnetic
8, 54, 73, 84, 94, 103, 113, 133, 155, 166, 195, 215, 2005, 2053 Antiferromagnetism film
9, 21, 55, 74, 85, 114, 134, 156, 167, 197, 208, 216 Laminating length bias layer
10, 22, 56, 75, 76, 92, 96, 101, 104, 106, 115, 141, 172, 174, 182, 184, 209, 222, 224, 235 Electrode lead layer
11, 23, 61,105,142,206,248 Cap layer
24 Laminating Fixed Magn tic Layer
25 Laminating Free Magnetic Layer
30 Substrate
31,231 Lower shield layer

32,232 Lower gap insulating layer
51, 82, 121, 162, 181, 183, 207, 210, and 223 a mushroom -- type resist
62,236 Up gap insulating layer
63,237 Up shield layer
64,238 The magnetoresistance-effect type thin film magnetic head for reproduction
91, 95, 171, 173, 221, 705, 1101, 1906 Electrode lead layer membrane
122, 151, 161, 191, 211, 2001 The 1st nonmagnetic membrane
123, 152, 163, 192, 212, 2002 The 1st ferromagnetic
131, 153, 164, 193, 213, 2003 The 2nd nonmagnetic membrane
132, 154, 165, 194, 214, 2004 2nd strong ****
234 Vertical Bias Layer
240 Induction-Type Thin Film Magnetic Head for Record
241 Record Gap Layer
242 Up Magnetic Pole
243 Coil Coil
249 Reproduction Head Gap Length
701 Non-magnetic Layer Film
702 Ferromagnetic Layer Membrane
703, 1505, 1905 Antiferromagnetism layer membrane
1501, 1901, 2007 1st non-magnetic layer film
1502 1902 1st ferromagnetic layer membrane
1503 1903 2nd non-magnetic layer film
1504 1904 2nd ferromagnetic layer membrane
2006 1st Fixed Magnetic Layer Film
2008 2nd Fixed Magnetic Layer Film
2011 1st Free Magnetic Layer Film
2012 2nd Free Magnetic Layer Film
2013 N-th Free Magnetic Layer Film

[Translation done.]